POWER PLANT ENGINEERING

Established Over 35 Years

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Power Problems of the Ark

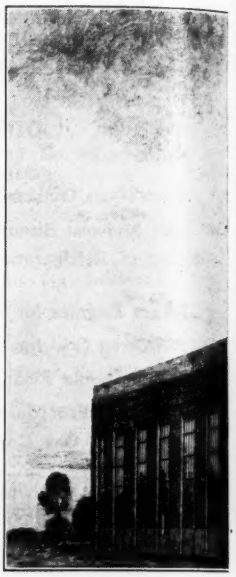
AT THIS LATE date it would certainly be unbecoming of us to criticize old Abraham Noah's method of preserving the land-animal life of his day. He did the best he could and as a naval architect he is the alpha. But as a power engineer—well Noah solved his problems but what efficiency could he get out of those old hay burners?

At that, the elephant was probably better than a company of slaves; there were fewer units to control and direct and they had intelligence; the fuel for the elephant is cheap compared with that for slaves, the cubical space per erg capacity is probably in favor of elephant power and certainly old Jumbo made a more interesting picture to hand down to posterity than a grab bucket, cable and crane.

Nobody, however, has ever told us how second mate Ham Noah propelled the ark around so it docked just the way he wanted it without smashing the wharf on Mt. Ararat. Certainly no picture was ever taken of the ark equipped with sails or a smoke stack spreading its stream of black smoke across the horizon. The most likely guess that we can make is that Noah had domesticated Jonah's whale and drafted him into service for the particular service.

Be all this as it may, we are indebted to Warner Bros. for preserving this picture of the Leviathan's Adam during its construction and even though Noah was not a power engineer it would be interesting to know what he would have thought of powdered coal as compared with a whale for motive power for ships. Dr. Goos champions powdered coal in his article on page 504 of this issue. Now let some disciple of Noah present the other side of the question.

"BREMO"—An Out-



Bremo Station of The Virginia Public Service Co. which is just being placed in operation is without question the most outstanding station constructed in recent years. With 15,000 k.w., 3600 r.p.m. turbines, full centralized control, vertical single pass boilers, direct contact heaters, and diphenyl-oxide air heaters, the station possesses more new features of engineering interest than any station thus far constructed

SOME 30 MILES SOUTH of Charlottesville, Va., at a little village on the James River known as Bremo Bluff, the Electric Management and Engineering Co., of New York, is completing the construction of a new steam electric generating station for the Virginia Public Service Company to be known as the Bremo Plant.

As central stations go, this plant is one of moderate capacity, the initial installation which is now about ready to go into operation being rated at 30,000 kw. while an ultimate capacity of 150,000 kw. is planned for. So, from a standpoint of magnitude, the Bremo plant will excite no particular interest in the engineering world but from every other angle this station is undoubtedly one of the most interesting of any constructed within recent years. Not since the South Amboy Station[1] was placed in operation last year has anything so new or different been presented to the power plant world. For not only is the general design of this station characterized by new ideas but much of the equipment—the boilers, turbines and auxiliaries—is of new and improved design.

From this it must not be inferred that Bremo is a freak station—an experiment for the purpose of trying out a number of new ideas, for it is not. There is nothing in the plant for which the engineering features have not been fully worked out. The station represents an advance in power plant design and all the new features show either an increase in efficiency over conventional methods or have certain operating advantages.

As in the case of South Amboy which was designed by the same engineers, the final design of Bremo is the logical consequence of the utmost freedom and co-operation between the designing engineers and the manufacturers, an effective utilization of the full resources of each and a definite understanding of the ultimate object in view on the part of all concerned. Sound engineering characterizes every detail of the station and the whole is as fine an example of coördination of effort and experience as is to be found anywhere.

Before proceeding with a description of the details of this interesting power plant, it will be of interest to enumerate briefly the outstanding features as follows:

1. Centralized control. This is the first station that has come to our attention in which the control of the entire plant, boiler and turbine room and electrical switching is centralized in a single control room under the supervision of a single operator.

2. Diphenyl oxide air preheaters. A new idea in preheating air for combustion, incorporating the use of an intermediate heat exchanging medium and separate heat absorbing and heat releasing elements.

3. Inclined tube, single-pass boilers with tapered gas pass. These are the first units of this kind to be installed and incorporate the most modern theories of boiler design and practice.

4. Fifteen thousand-kilowatt, tandem-compound, 3600-r.p.m. turbines, the largest 3600-r.p.m. condensing units built thus far in this country.

5. Rain-type, direct-contact extraction heaters, discharging to suitable pressure stages of a multi-stage condensate pump.

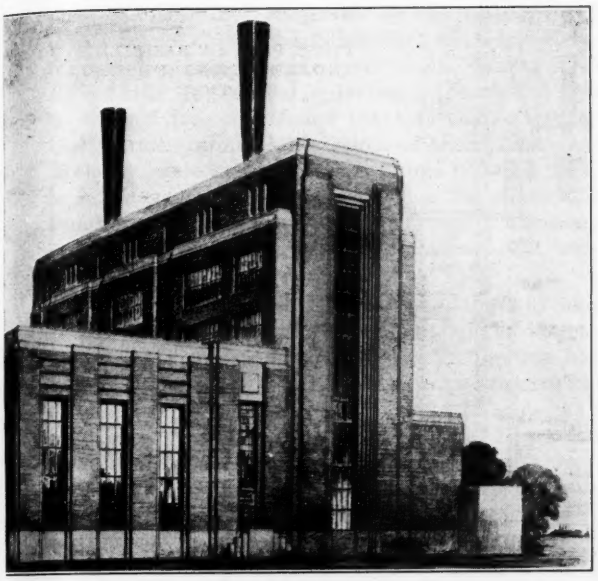
6. Automatic temperature control of steam to turbine by means of desuperheaters under thermostatic control.

7. Premeasurement of fuel and air in combustion, involving several burners per boiler, each with its individual mill and fan equipment all under remote control.

Some of these features were incorporated in South Amboy station, others are entirely new and some which were used at South Amboy have been improved upon. Thus, while direct contact extraction feedwater heaters were used in the New Jersey station, they were of the jet type while these installed at Bremo are of the so-called "rain" type. The reason for using this type of heater is to secure greater efficiency at low loads. The rain type heater can operate at zero load, while the jet

[1] July 15, 1930 issue.

Standing Central Station



type heater is limited to a load range of approximately 5 to 1.

Plant Designed on the "Unit" Principle

Bremo station is designed upon the unit principle, that is, the equipment is so divided and so arranged that each boiler and turbo-generator together with its associated auxiliaries may operate as a unit without respect to other parts of the station.

At present the principal equipment consists of two 15,000-kw.turbo-generating units and two 19,836-sq. ft. boilers built for 525-lb. pressure and designed to deliver 200,000 lb. of steam at maximum load. Each boiler serves its own turbine although the piping is arranged so that the units may be interconnected. Space also has been allowed for the installation of a third boiler so as to provide a reserve unit, but at present this will not be installed.

This unit idea has been carried on throughout the entire cycle of power generation, from the pulverizing mills in the boiler room to the leads to the outdoor switching station. Not only is each boiler furnace provided with its individual system of coal preparation, but each of the three burners serving each furnace has its individual mill, fans and heaters. This applies also to the boiler feedwater system; each unit has its own feed pumps in duplicate, condensate pumps in duplicate, evaporators and extraction heaters and operates as a unit. This results in a logical and convenient arrangement of equipment and one that entails a minimum amount of piping, since all the apparatus associated with one unit is grouped together. The simplicity of the arrangement will be evident from the accompanying drawings.

Another feature of interest in this station is the fact that although at present it will operate with steam having a total temperature of 750 deg., it is designed and all equipment built for ultimate operation at 825 deg. should that be deemed desirable.

Several Features

Bremo station is located on the bank of the James River and is served by the Chesapeake and Ohio Railroad. The station is thus favorably situated as regards condensing water and coal supply. The main line of the railroad runs between the river and the plant. The screenhouse is located some distance from the river, near the plant proper, in order to bring it within the station property line which parallels the railroad and, also, to avoid the expensive foundation construction which would have been necessary had the screenhouse been placed on the river bank.

Architecturally the station is pleasingly attractive. Its mass is well proportioned and the red pressed brick facing and white stone trim provide it with a dignity worthy of its purpose. The building is amply lighted by large windows set in steel sash on all sides. The

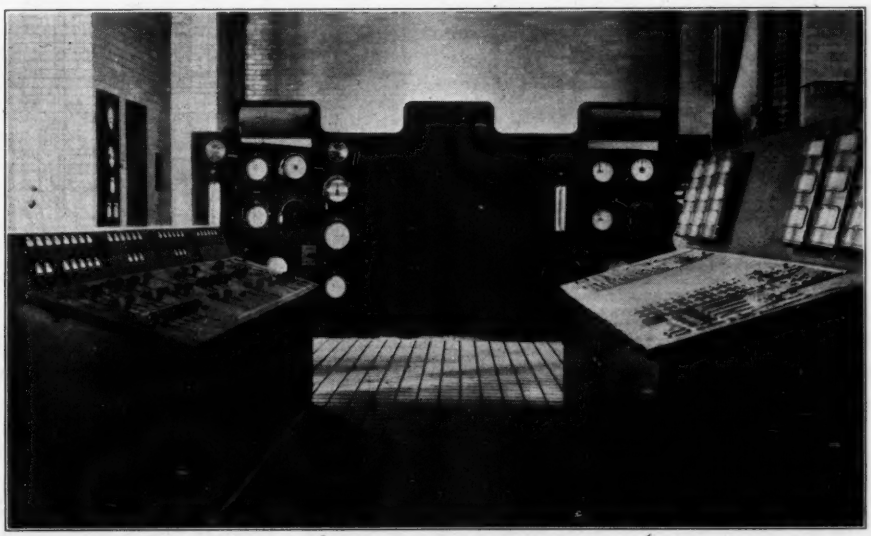


FIG. 1. THE ENTIRE "CONTROL" FOR BREMO STATION IS CENTRALIZED IN THIS CONTROL ROOM

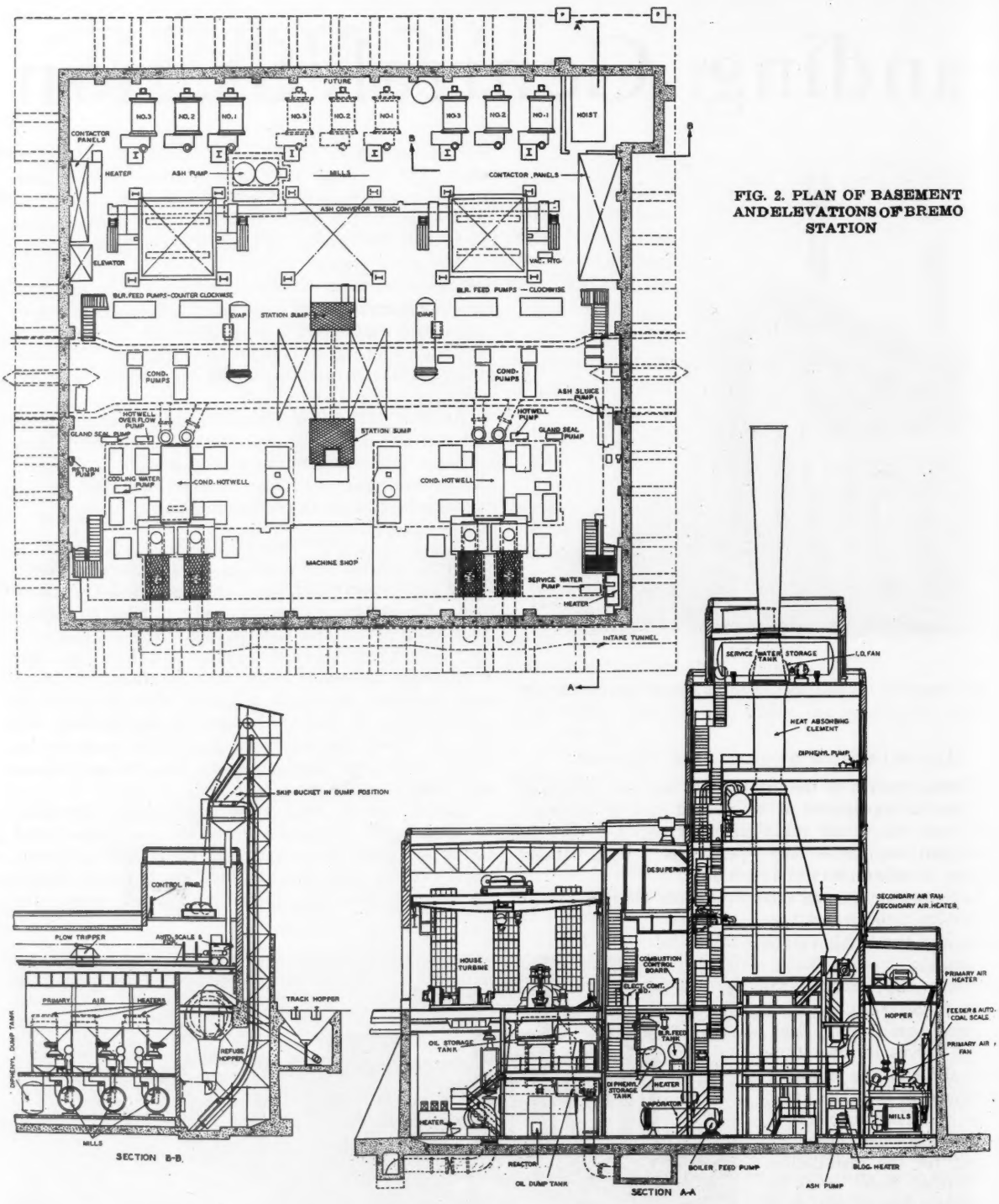


FIG. 2. PLAN OF BASEMENT AND ELEVATIONS OF BREMO STATION

front of the station faces the river, the arrangement being such that future growth will be in a direction away from the river.

The two 15,000-kw. generating units are placed symmetrically with respect to each other and to the boilers. The boiler and turbine rooms are separated by a central bay which contains the electrical and steam control equipment, feedwater heaters and associated equipment. This feature differentiates Bremo from the usual design of central station where the electrical bay is located on the side of the turbine room away from the boiler room. Here, however, the control of the entire station, boiler and turbine room, is centralized in one control room. Naturally, the logical place for such a control room is in the center of the station where the operators may most easily observe conditions in both of the major divisions of the plant. The main control room, it will be noted is on the same level as the turbine floor. The room directly above this control room is given up to the auxiliary electrical control equipment

and to the station storage battery while the floor below contains all the feedwater heaters and associated storage tanks and equipment. Two 10,000-gal. house service water storage tanks are installed on the induced draft fan floor in the boiler house, for cooling water and general house service.

Each main turbine is served by a single-pass surface condenser in turn served by two bottom suction, top discharge circulating pumps and one triple element three-stage steam jet air ejector, each element having air capacity for normal operation. Circulating water is obtained from the James River through a concrete-lined tunnel running the length of the station and is discharged into another similar tunnel running parallel to it. Excavation was carried down to bed rock, the basement floor being just above the rock. Thus, the intake and discharge tunnels are practically cut out of solid rock.

Heat balance of the station is maintained by means of the extraction heating system, all auxiliaries being driven by 550-v. motors. A 1000-kw. spinning house turbo-generator is provided, but the auxiliaries normally derive their supply from station transformers tapped into the system between the generators and transformers. This house turbo-generator is normally connected to the auxiliary system and operates as a synchronous condenser; the turbine is so designed that it can operate continuously in this manner without steam for cooling.

In the boiler room, steam is generated at a pressure of about 500 lb. in two vertical, single-pass, inclined tube boilers provided with completely water-cooled walls, slag tap type furnaces and fired by pulverized coal. Air for combustion is heated by a new form of air preheating equipment incorporating the use of diphenyl oxide as a heat transfer agent between the heat absorbing element in the gas passage to the stack and the heat releasing elements in the primary and secondary air supply ducts to the furnaces. The combustion system involves premeasurement of coal and air and all control is from the central control room already referred to.

Make-up feedwater is from a well or is river water pumped from the condenser discharge tunnel directly to the evaporators. Feedwater is heated in four stages by direct-contact extraction heaters and is delivered to the boilers at a temperature of approximately 400 deg.

All high-pressure steam piping 2½ in. and larger is provided with Sarlun joints while high pressure steam and water piping less than 2½ in. with large male and female joints.

Coal Handling

Coal delivered to the plant is dumped into a track hopper and is reduced in size by means of a Bradford breaker located inside the building as shown in Fig. 2. This breaker is provided with a bypass so that coal which is fine enough may be sent directly to the plant or to storage as desired.

All coal, whether intended for immediate use or for storage, is handled by the skip hoist which receives the coal after it has passed through or around the breaker. Coal for storage is delivered by the skip hoist through a spout to the outside of the building and from there it is distributed throughout the storage area by a drag scraper system. By means of a tail car running on a 400-ft. radius track, coal can be stored anywhere within the area of the storage yard.

Coal for immediate use is delivered to the bunkers installed directly over the pulverizing mills. The arrangement will be evident from the drawings, the skip hoist delivering to an automatic scale and feeder, this

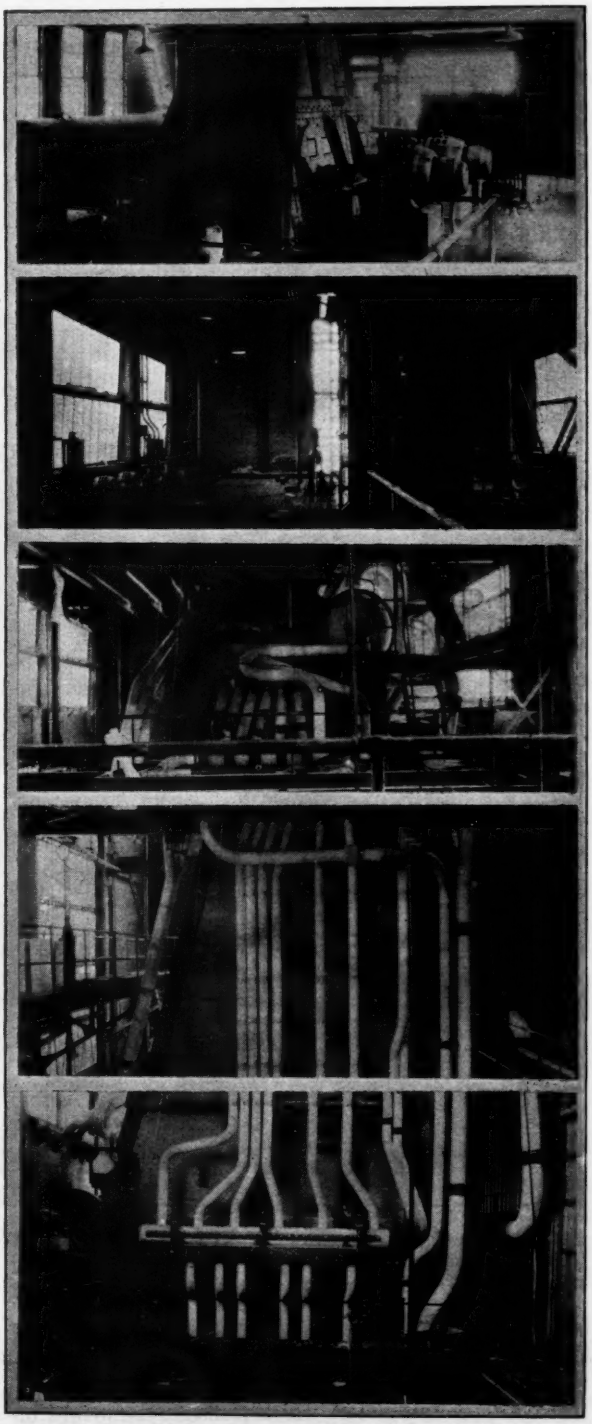


FIG. 3. VIEWS IN THE BOILER ROOM SHOWING (FROM TOP TO BOTTOM RESPECTIVELY) INDUCED DRAFT FANS, HEAT ABSORBING ELEMENT AND VERTICAL SINGLE PASS BOILER

in turn, delivering to a belt conveyor provided with a traveling tripper.

From the bunkers the coal passes to a number of disc feeders one for each mill, which control the quantity of coal being delivered to the mills at all times, and then to an electrically-operated scale which continuously records the amounts of coal being delivered. This equipment consists of a short belt conveyor carried by a scale so that as the coal passes over the conveyor, the weight is measured by the scale. The scales are provided with Selsyn motors which transmit the weight indications to the main control room above. At the same time, the amount (weight) of air supplied to the burners is also measured and the indications transmitted to the control room. The weight of primary air, the weight of secondary air and the weight of coal are each indicated by pointers and dials in a three part instrument, the lower section of the dial indicating the pounds per hour in each case and the upper section being a rating chart with an adjustable hair line by which the operator can make his proper proportions of the combustible mixture by merely controlling his apparatus so that the pointers are at the same rating on all three dials of the same instrument. The exact amount of coal and air supplied to the furnace is therefore under the observation of the operator in the control room at all times.

Altogether there are six complete pulverizing units, three for each boiler and each complete in itself. Each

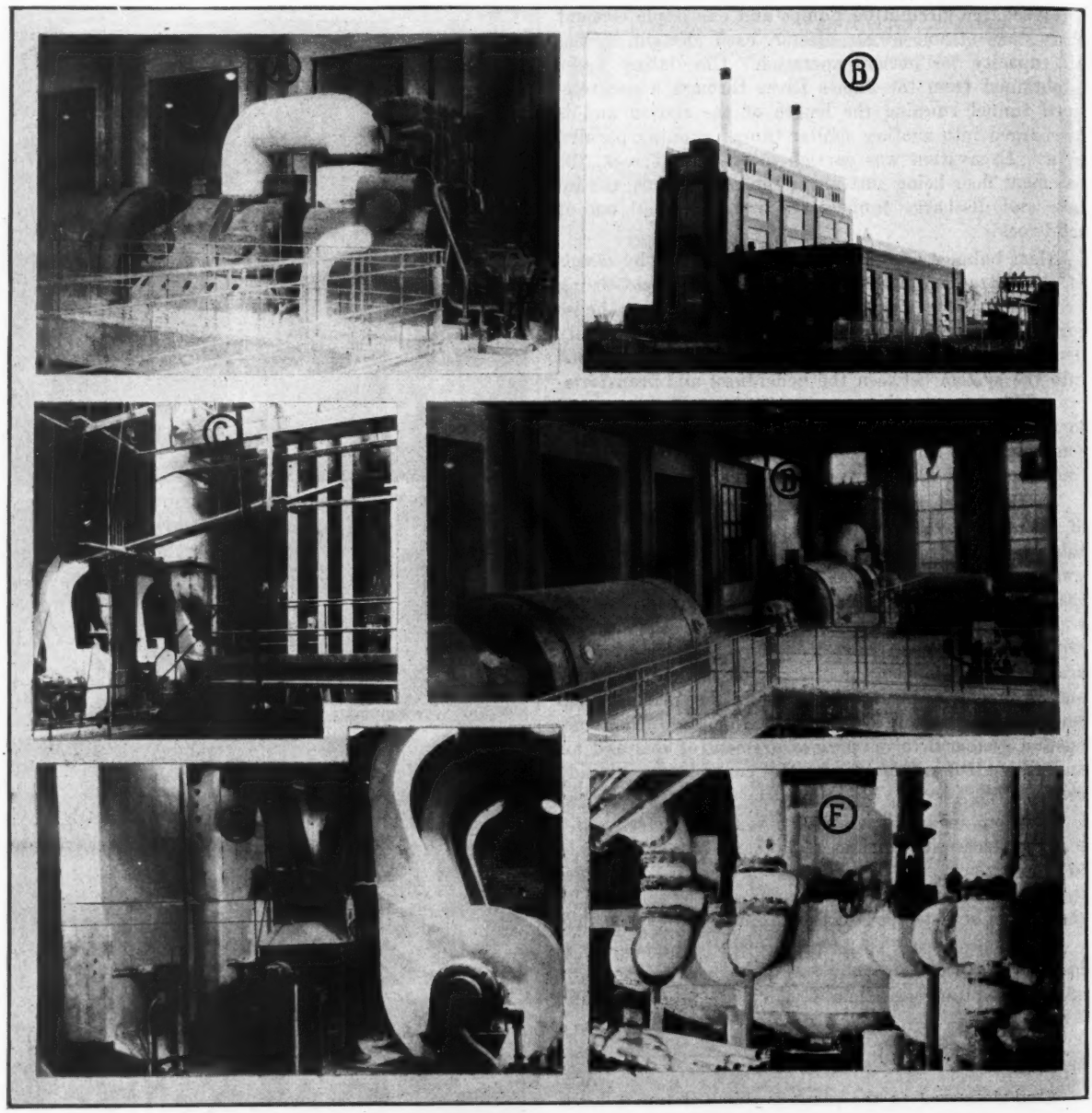


FIG. 4. VARIOUS VIEWS AT BREMO STATION

A. One of the 15,000-kw., 3600-r.p.m. turbo-generators. B. An outside view. C. In the boiler room. D. General view of turbine room. E. The primary air fans, coal feeders and primary air heaters. The latter may be noted at the left, two heaters being visible in the photograph. F. Insulation being applied to direct-contact heaters.

unit consists of a primary and secondary air heater, primary and secondary air fans, feeders, scales, pulverizing mills and burners.

Influence of Boilers on Design of Boiler Room

Before proceeding with a description of the combustion equipment it will be of interest to consider briefly the boiler room as a whole. As may be noted from the cross section of the plant, the shape of the boilers and the arrangement of equipment is quite different from conventional designs. In the design of this plant an effort was made to simplify the boiler room layout as much as possible and as a nucleus for the attainment of this object, the vertical, single-pass boilers

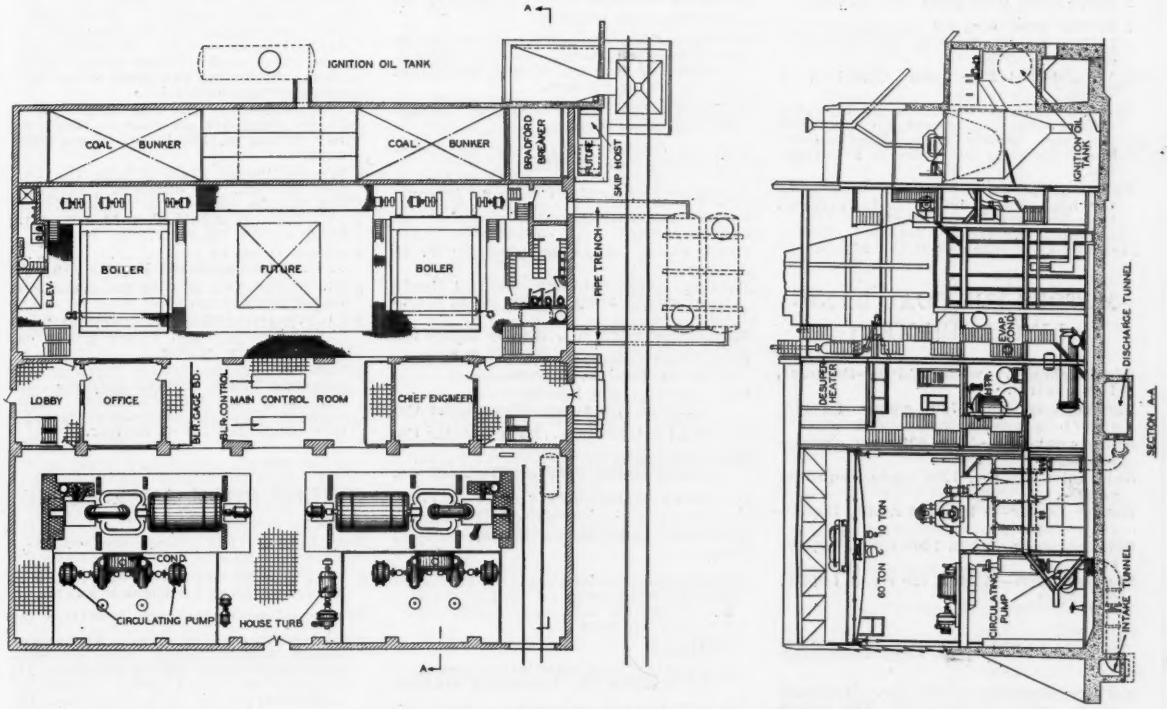


FIG. 5. PLAN OF MAIN TURBINE FLOOR AND SECTION

were selected. These boilers, having no baffles, provide an absolutely straight tapered gas path from the furnace to the stack.

The design of the boiler room was a necessary consequence of the use of this type of boiler. A unit of this type is high and narrow hence the duct work associated with the usual type of air preheating equipment would be long, and therefore, expensive and also would entail considerable draft loss. This difficulty, however, in this case is eliminated by the use of the diphenyl oxide air heating system.

Diphenyl Oxide Air Preheating System

This system as indicated previously, consists of a heat absorbing element in the gas path of the boiler and several heat releasing sections placed in the air supply ducts of the same boiler. The heat absorbing element is quite similar to an extended surface economizer. Each heater at this station contains 16,128 sq. ft. of external heating surface. The heat releasing or heat liberating units are also of the extended surface type using fin tubes, those used for heating primary air having 2170 sq. ft. of surface and those for secondary air 6108 sq. ft. The actual arrangement will be evident from the cross sections, Figs. 2 and 5. The heat absorbing element is placed directly over the top of the boiler, the exit gases passing vertically upward from the boiler, through the heater to the induced draft fans in the base of the stack. The heat liberating elements, of course, are placed close to the mills and furnaces with which they are associated.

Heat from the absorbing element is transferred to the heat releasing elements by the circulation of a mixture consisting of 85 per cent diphenyl oxide and 15 per cent naphthylene. This is circulated by means of a small centrifugal pump through a 3-in. line. This, it will be evident, eliminates all the duct work which normally is required between the air heater and the furnaces. The diphenyl oxide system is entirely closed, an expansion tank on the heater floor providing for variations in volume.

Diphenyl oxide is peculiarly suited to serve as a heat transfer medium for it can be heated to a relatively high temperature at a comparatively low pressure. In the pure state it solidifies at a temperature of 80.6 deg. F. and since there might be danger of it "freezing" in the system it is mixed with naphthylene to lower this freezing point.

Splitting up of the heat liberating elements into primary and secondary air heating units has advantages other than that of simplifying the duct layout. It allows the primary and secondary air temperatures to be varied separately. In planning this system, it was recognized that there are limits beyond which the temperature of the primary air supplied to the furnace cannot be increased due to its effect upon the operation of

Principal Initial Equipment at Bremo Station

COAL HANDLING EQUIPMENT

All coal handling equipment supplied and installed by Freeman-Riff Co.

1 14 by 20-ft. steel track hopper.

1 30-in. by 29-ft. long apron conveyor.

1 9 by 14-ft. Pennsylvania standard Bradford Breaker, 100-ton-hr. capacity.

1 Single bucket, counter-weighted, full automatic skip hoist.

1 18 by 18-in. rotary feeder.

1 30-in. by 133-ft. long belt conveyor complete with supporting framework.

2 Suspension type steel coal bunkers.

1 Power drag scraper equipment complete (4½-yd. bucket) 110 ton-hr.—Sauerman Bros.

1 Weightometer — John Chatillon & Sons.

Speed reducers—W. A. Jones Foundry & Machine Co., except for Bradford Breaker, which is a Herringbone Speed Reducer by Gears & Forgings, Inc.

Falk Corporation flexible couplings for high speed drives and Universal type low speed couplings.
Cincinnati Rubber Co. belts.
Robbins Conveying Belt Co. idlers.

MOTORS FOR COAL HANDLING EQUIPMENT

Westinghouse, with Cutler-Hammer, Inc. control.
Breaker—40 hp., 720 r.p.m. (wound rotor).
Apron conveyor—5 hp., 600 r.p.m. (squirrel cage).
Skip hoist—15 hp., 1200 r.p.m. (squirrel cage).
Rotary feeder—3 hp., 600 r.p.m., (squirrel cage).
Belt conveyor—5 hp., 1200 r.p.m. (squirrel cage).
Drag scraper—125 hp., 720 r.p.m. (squirrel cage).

ASH HANDLING EQUIPMENT

1 Allen - Sherman - Hoff Co. Hydrojet sluice with a 980-g.p.m. ash sluice pump and a 1200-g.p.m., 400-ft. sluice supply pump furnished by Dean Hill.

BOILER EQUIPMENT

2 Babcock & Wilcox Co. single-pass, inclined straight tube, cross-drum, water-tube boilers, designed for 525-lb. pressure, 825 deg. total steam temperature. Normal output, 180,000 lb. hr.; maximum output, 200,000 lb. hr. Heating surface, 19,836 sq. ft., 4-in. tubes, 12 to 20-ft. long, 30 sections wide, 39 rows high.

2 Babcock & Wilcox Co. interdeck convection steel superheaters, return bend type; designed to superheat the boiler output to 825 deg. F. total temperature.

2 Babcock & Wilcox Co. desuperheaters, submerged bent-tube type, thermostatically controlled to maintain the total steam temperature at 825 deg. F.

2 Foster Wheeler Corp. counter current flow heat absorbing elements for remote air preheating. Each unit is 24 rows high, 14 rows wide, with elements 16 ft. long over rings, and contains 16 128-sq. ft. external heating surface.

6 Griscom-Russell Co. (K-Fin) heat liberating units for primary air heating, 2170 sq. ft. each.

6 Griscom-Russell Co. (K-Fin) heat liberating units for secondary air heating, 6108 sq. ft. each.

PULVERIZERS AND FURNACES

6 Kennedy-Van Saun Mfg. & Engr. Corp. air swept, ball pulverizers; capacity, each 6700 lb. per hr. Each mill equipped with a rotary feeder, a special belt conveyor for weighing the coal, and an exhauster.

6 Fairbanks, Morse & Co. Special Dormant Scales arranged to carry the above conveyors and with an attachment for Selsyn motors.

6 Foster Wheeler Corp. horizontal intertube type burners.

2 Foster Wheeler Corp. completely water-cooled furnaces, each with a volume of 9400 cu. ft. and with 1838 sq. ft. water surface.

1 Boiler Instrument Panel built by McGibbon Iron Works.

1 Boiler Control Panel built by Westinghouse Elec. & Mfg. Co.

Equipment on Boiler Panels as follows:

Special combustion control.....Bailey Meter Co.

Draft gages—Hays, supplied by P. B. Huyette Co.

Remote water columns, McNeill liquid level gages supplied by A. B. Carle Co.

Steam flow meters.....Bailey Meter Co.

Boiler feedwater meter; Cochrane, supplied by Paul B. Huyette Co.

CO_2 Indicator and Recorder.....Republic Flow Meter Co.

Coal feed integrators..Bailey Meter Co.

Pressure gages .....Consolidated Ashcroft Hancock Co.

Recording thermometers .....Taylor Instrument Co.

Electrical controls on Boiler Control Panel—

Induced draft fans
Ignition oil pumps
Secondary air fans
Primary air fans
Mills
Feeders
Air heater fluid circulating pump
Valve control and indicating station.

EXHAUSTERS, FANS AND STACKS

2 Prat-Daniel Corp. Thermix steel stacks, 1 per boiler, each stack containing 2 induced draft fans in its base designed to handle 84,600 c.f.m. max. at 325 deg. F. against 3.5-in. w.g. Stacks are 60 ft. high above the roof and are 8 ft. diameter at the top.

6 Buffalo Forge Co. secondary air fans, each fan designed to deliver 13,450 c.f.m. against 11.2-in. w.g.

6 Kennedy Van Saun Mfg. & Eng. Corp. primary air fans (exhausters on mills), each 24,000 lb. air per hour at 480 deg. F. against 5½-in. w.g.

Flue connections and air ducts furnished and installed by Connery & Co.
Damper control.....Garrick Engrg. Co.

TURBO-GENERATORS AND AUXILIARIES

2 Westinghouse Elec. & Mfg. Co. tandem compound turbine generators, each 15,000 kw. at 80 per cent p.f. 13,800-v., 3-wire, 60-cycle, 3-phase, 2-pole, 3600-r.p.m., 85-kw., 250-v. shunt wound direct-connected exciters. Surface type generator air coolers, 5570-sq. ft. surface generator ventilating fans on generator shaft. Turbine, 450 lb., 825 deg. F. total temp. steam at the throttle, 15 stages in hp. cylinder and 8 stages in l.p. cylinders. At normal full load, the extractions for feedwater heating are at the following pressures: 4th stage, 201.5 lb. per sq. in. abs.; 11th stage, 65.9 lb. per sq. in. abs.; 5th stage, high pressure cylinder exhausts 23.8 lb. per sq. in. abs.; low-pressure cylinder, 4.14 lb. per sq. in. abs.; back pressure, 1 in. Hg. abs. Lead plate diaphragm blow-offs in l.p. turbine casing.

2 Westinghouse Elec. & Mfg. Co. horizontal single pass, radial flow condensers of 13,000 sq. ft. surface each. Surface composed of 2838, ⅞ in. dia. No. 18 BWG Admiralty metal tubes, 20 ft. in length. Tubes expanded into both tube sheets. Floating type tube sheet on discharge ends of tubes. Each condenser equipped with 4000-gal. storage hotwell.

2 Westinghouse Elec. & Mfg. Co. 3-stage steam jet air ejectors designed to operate on 350-lb. g. steam pressure.

4 Westinghouse Elec. & Mfg. Co. bottom suction, top discharge, circulating pumps, each with a capacity of 14,250-g.p.m. against a 14.7-ft. total head at 290 r.p.m., 75-hp. motors.

Vacuum trippers .....Consolidated Engine Stop Co.

2 Pittsburgh-Des Moines Co. gland seal water storage tanks.

2 Link-Belt Co. Model D vertical traveling screens, each 28,000 g.p.m. capacity at low water.

1 1000-kw. Terry Steam Turbine Co. spinning house turbine directly connected to an Allis-Chalmers 600-v., 3-phase, 60-cycle alternator with direct-connected 250-v. exciter.

BOILER ROOM ACCESSORIES

Soot blowers for boilers and economizers..Diamond Power Specialty Co.

2 5-in. Type B1 Copes feedwater regulators, supplied by Kissick-Fenno Co.

Water columns..Babcock & Wilcox Co.

High pressure steam piping 2½ in. and larger Sarlun joints, high pressure steam and water piping less than 2½ in. large male and female joints.....Pittsburgh Piping & Equipment Co.

Fittings, electric cast steel.....Pittsburgh Piping & Equip. Co.

Consolidated Ashcroft Hancock Co. safety valves—On boiler drum, 2 to 3 in.; on superheater, 1 to 3 in.

Yarway tandem blowoff valves — mud drum, 2 2½-in., water wall lower headers, 4 1½-in.

Boiler valves: High pressure gate.....Chapman Valve Mfg. Co.

High pressure globe valves.....The Edward Valve & Mfg. Co.

Check valves and motor operated non-return valves .....The Edward Valve & Mfg. Co.

Motor controls for non-return valves .....Limitorque; others by Chapman Valve & Mfg. Co.

Thermostatic controls and valves for maintaining constant total steam temperature.....Bailey Meter Co.

Gratings and stairways "Mitco," supplied by Ingalls Iron Works.

FEEDWATER SYSTEM

2 Griscom-Russell Co. evaporators for make-up water, capacity each 5000 lb. per hr.; return tube type, single effect, maximum shell pressure 100 lb., maximum tube pressure 100 lb. Normally supplied with 65 lb. steam at normal full load.

Principal Initial Equipment at Bremo Station

2 Griscom-Russell automatic float feed controls for evaporator feed control.

2 Griscom-Russell evaporator condensers, 2-pass, removable bundle pattern and equipped with condenser type water head. Capacity, 5000 lb. vapor per hour plus flash from tube drains from evaporator. Tubes and heads, 125 lb. per sq. in. shell, 70 lb. per sq. in.

Foster Wheeler direct-contact extraction heater system, consisting of eight extraction heaters, four per turbine, rain type direct-contact, each with vent condenser. At normal full load, heater No. 1 takes steam from 5th stage of low pressure turbine at 4.14 lb. absolute, 4½ per cent moisture, and heats 109,720 lb. of water per hour from 88 deg. F. to 151 deg. F. Heater No. 2 takes steam from the high pressure turbine exhaust, (15th stage) at 23.8 lb. absolute, 42 deg. S.H. and heats 119,310 lb. of water per hour from 151 deg. F. to 236 deg. F. No. 3 heater takes steam from the 11th stage of the high pressure turbine at 65.9 lb. absolute, 145 deg. S.H. and heats 129,810 lb. of water per hour from 263 deg. F. to 297 deg. F. No. 4 heater takes steam from the 4th stage of the high pressure unit at 201.5 lb. per sq. in. absolute, 275 deg. S.H. and heats 142,640 lb. of water per hr. from 297 deg. F. to 382 deg. F.

and

4 Special centrifugal multi section condensate pumps, two per turbine, one regular and one reserve, in four sections each. At normal full load, the requirements of the sections are: No. 1 section, 219 g.p.m., 79 deg. F., 29-in. Hg. vacuum to 43 ft. w.g. No. 2 section, 243 g.p.m., 151 deg. F., 16 ft. to 82 ft. w.g. No. 3 section, 273 g.p.m. 236 deg. F., 61 to 196 ft. w.g. No. 4 section, 310 g.p.m., 297 deg. F., 167 to 531 ft. w.g.

4 5-in. suction and 4-in. discharge type ML, 5-stage, double suction Allis-Chalmers Mfg. Co. boiler feed pumps, capacity, 500 g.p.m. against an 880-ft. net head. Direct connected to Allis-Chalmers constant speed motors, 1750 r.p.m., 150 hp.

MISCELLANEOUS PUMPS AND COMPRESSORS

2 Dean Hill Pump Co. gland water pumps, capacity 10 g.p.m. at 140-ft. head.

2 Dean Hill Pump Co. evaporator feed pumps, capacity 16 g.p.m. at 150-ft. head.

2 Dean Hill Pump Co. hotwell overflow pumps, capacity 100 g.p.m. at 70-ft. head.

2 Dean Hill Pump Co. flash tank drain pumps, capacity 25 g.p.m. at 84-ft. head.

2 Dean Hill Pump Co. low level storage pumps, capacity 125 g.p.m. at 110-ft. head.

2 Dean Hill Pump Co. station sump pumps, capacity 50 g.p.m. at 50-ft. head.

2 Dean Hill Pump Co. booster pumps for generator air and oil cooler circulating water, capacity 500 g.p.m. at 10-ft. head.

1 Whiting Corp. electric overhead traveling crane; 60-ton main hoist, 10-ton auxiliary hoist.

1 Ingersoll-Rand Co. type 20, single-stage, single-acting, vertical, duplex air compressor 7 by 6 in.

4 Foster Wheeler Corp. Diphenyl circulating pumps, capacity 200 g.p.m. at 270-ft. head.

2 Schutte & Koerting ignition oil pumps, capacity 10 g.p.m. at 200-ft. head.

1 Schutte & Koerting lubricating oil transfer pump with direct-connected motor; capacity 46 g.p.m. at 15 lb. per sq. in.

Power distribution cabinets.....Bulldog Electric Co.

Motor generator set (spare exciter)..Westinghouse Elec. & Mfg. Co. Generator: 85 kw., type Sk, shunt wound, 250 v.

MOTORS FOR AUXILIARY DRIVES

All motors are 550-volt, 3-phase, 60-cycle, except as noted.

Quan.	Service	Manufacturer	Type	H.P.	R.P.M.	Speed Control
4	Circulators	Westinghouse	CS	75	290	
4	Condensate Pump	Allis-Chalmers	Slip Ring ARY	125	1800	GE
4	Boiler Feed Pump	Allis-Chalmers		150	1750	
2	Circ. Water Screens	General Electric	KT	7½		
1	Ash Sluice Pump			75	865	
1	Ash Sluice Supply	Fairbanks-Morse	H	200	1800	
6	Pulverizer Drive	Fairbanks-Morse	H Sq.C.	60	690	
6	Scale Drive	General Electric	Induction SAS	1/10	1800	
6	Feeder Drive	Star Electric Co.	DC	¼	600-2000	Cutler-Hammer
6	P. Air Fans	Fairbanks-Morse	Slip Ring	30	1200	GE
6	Sec. Air Fans	Fairbanks-Morse	Slip Ring	30	1800	GE
4	Induced Draft Fans	Fairbanks-Morse	Slip Ring (60% Reduc.)	40	720	GE
2	Gland Water Pump	Fairbanks-Morse	Q	5	1800	
2	Evap. Feed	Fairbanks-Morse	Q	5	1800	
2	Hotwell Overflow	Fairbanks-Morse	Q	5	1800	
2	Flash tank drain	Fairbanks-Morse	Q	5	1800	
2	Low level storage	General Electric	KT Vertical	10	1800	
2	Station Sump	Fairbanks-Morse	UHA Vertical	2	1800	
2	Booster—air and oil coolers			2	870	
1	Air compressor	General Electric	KT	25	575	
4	Diphenyl Circ.	Fairbanks-Morse	Sq.C.	30	1800	
1	Crane Main Hoist	General Electric		30	845	
1	Crane Aux. Hoist	General Electric		30	845	
1	Crane Trolley	General Electric		10	865	
1	Crane Bridge	General Electric		10	845	

ELECTRICAL EQUIPMENT

7 6250-kv-a. single-phase outdoor type transformers, 66-kv./114.3-kv. "Y"—Moloney Electric Co.

7 400-kv-a. station auxiliary transformers, 13,200-550—Federal Electric Co., Inc.

3 25-kv-a., single-phase transformers, 550-v./119-v. station lighting—Federal Electric Co.

Control cable.....Okonite Co.

Cell structures.....Alberene Stone Co.

Switchgear equipment.General Elec. Co.

Battery.....Phila. Storage Battery Co.

Main generator leads..General Elec. Co. Hochstadter, type "H" cable, 3-sector, 750,000 CM 13.8 kv., impregnated paper, perforated copper tape for each conductor, steel tape overall, lead covered.

Main control board....General Elec. Co. Miniature type benchboard, consisting of 4 sections controlling 2 main generators, 2 banks of power transformers, 2 outgoing feeders, and house generator. Completely wired.

Station auxiliary switchboard.....General Elec. Co.

Exciter and metering board.....General Elec. Co.

Station lighting and d.c. control switchboard.....General Elec. Co.

Reactor .....General Elec. Co. Neutral grounding reactors, indoor type, 9.5 ohm, single-phase, 60-cycle, insulated for 7600 v., 800 amp. for one minute.

Motor generator set.....Westinghouse Elec. & Mfg. Co. Generator: 11 kw., type SK, 140 v., 2-wire, d.c.
Motor: 17-hp. induction motor, type "SC," squirrel cage rotor, 550-v., 60-cycle, 3-phase.

Motor: 125 hp., type CS, 3-phase, 60-cycle, 550-v., squirrel cage.

Ornamental lighting fixtures.....Bayley & Sons, Inc.

Highway lighting standards.....Veco Manufacturing Co.

Lighting distribution cabinets.....Westinghouse Elec. & Mfg. Co.

Bus supports and clamps.....Delta Star Elec. Co.

Grounding clamps.....Borden Elec. Co.

Bushings.....Ohio Brass Co.

Cable terminals and branch joints...General Cable Corp.

Safety switches...Cutler-Hammer, Inc.

Carrier current telephone equipment.....General Elec. Co.

Telephone booth.....J. E. Sjostrom Co.

MISCELLANEOUS

Building steel.....Ingalls Iron Works

Diphenyl expansion tanks, diphenyl storage tanks, diphenyl dump tanks.....Lancaster Iron Works

Fire extinguisher.....Walter Kidde Co.

Elevator.....Otis Elevator Co.

Sanacoustic ceiling in control room..H. W. Porter Co.

House generator air filter.....American Air Filter Co.

House generator air filter ducts.....Connery & Co.

Transformer car .....Easton Car & Cont. Co.

Coal sampling screens..W. S. Tyler Co.

No. 302 DeLaval-Funk process oil purifier, supplied by.....Westinghouse Elec. & Mfg. Co.

SPECIAL EQUIPMENT

Diphenyl oxide and Napthalene solution for use in remote air heaters.....Dow Chemical Co.

the mill and fan equipment, but that these limitations do not apply necessarily to the secondary air supply. Secondary air after being heated is usually delivered directly into the furnace and the temperature of the air does not affect the operation of important equipment as in the case of the primary air. Assuming the use of proper materials in the ducts, wind boxes, burners and heaters, there seems to be no top limit to the temperature of the secondary air, yet where both the primary and secondary air supply is served by a single heater as is customary, the temperature of the secondary air is limited to that of the primary air.

With the diphenyl oxide system using separate heaters this obstacle is removed entirely. The heat to both primary and secondary air can be accurately proportioned in accordance with fuel requirements and the heaters are so designed that very high secondary air temperatures can be attained. The primary air temperatures are controlled by restricting the flow of diphenyl oxide to the primary air heaters. The operation is exceedingly flexible.

Primary air is drawn into the top of the primary air heaters and after being heated part of it passes directly into the pulverizing mills and the rest is bypassed into the primary air fan. The secondary air fans take air directly from the interior of the boiler room and force it through the secondary air heaters into the burners. All air, primary and secondary, enters the furnace at the burners.

Three horizontal, double deck, intertube type burners are placed in the front wall of each furnace. Since each burner is supplied by its individual mill, and since each mill has a capacity of 6700 lb. of coal per hr. the total coal fed to one boiler at full load may be 20,100 lb. per hr.

In addition to three pulverized coal burners, each furnace is provided with four oil burners for starting purposes. These are installed in the side walls, two on each side so that the flame impinges with incoming coal streams to furnish power ignition. These oil burners are a new design which are electrically ignited and therefore may be controlled from a remote point.

The furnaces are completely water cooled and are provided with slag tap bottoms. Each furnace has a volume of 9400 cu. ft. and a water wall surface of 1838 sq. ft. The molten slag and ash is drawn from the furnace through a sluice in the side walls where it comes in contact with a cold water spray. The sudden cooling of the molten ash causes it to disintegrate and in the resulting finely divided state it is easily washed away. Both furnaces discharge into a common hydrojet sluice served by a 980-g.p.m. ash sluice pump and a 1200-g.p.m., 400-ft. head sluice supply-pump.

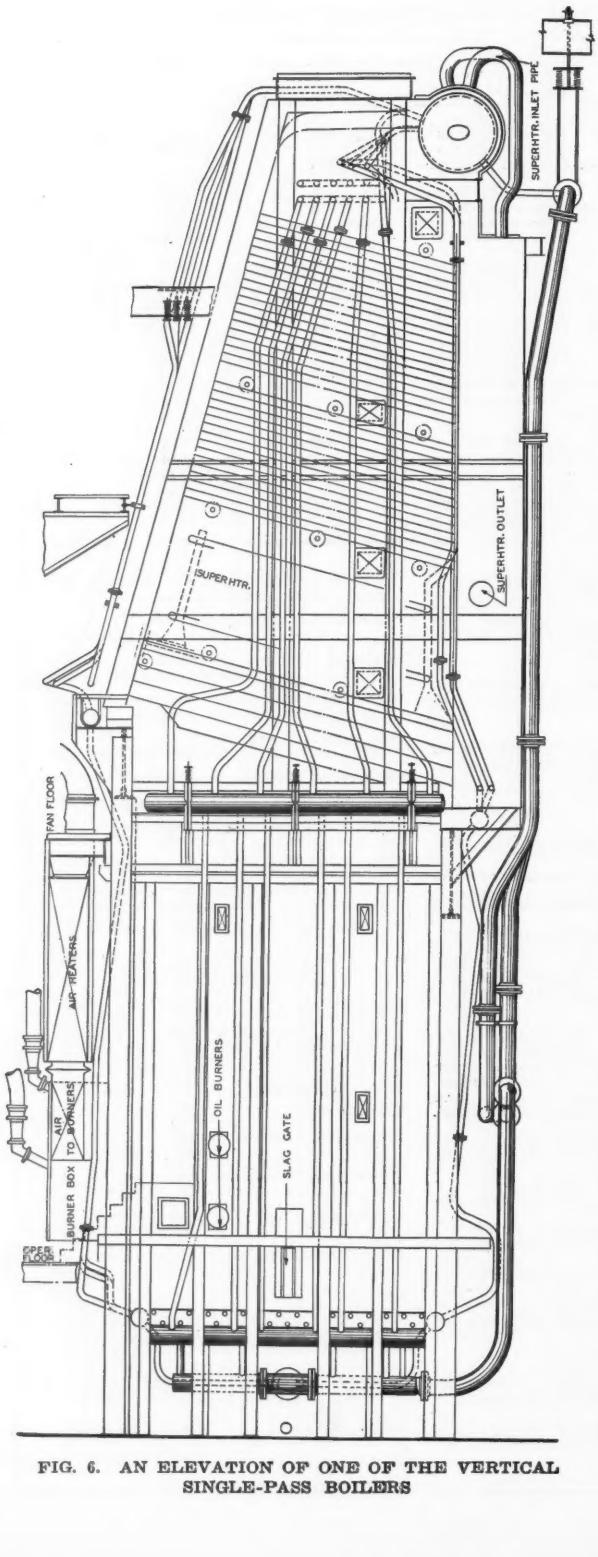


FIG. 6. AN ELEVATION OF ONE OF THE VERTICAL SINGLE-PASS BOILERS

Vertical, Single-Pass, Straight-Tube Boilers

With the exception of the system of preheating the air, perhaps the most interesting feature of this station lies in the design of the boilers. These are of an entirely new design in this country, and are known as vertical, single, tapered pass inclined straight tube, cross-drum boilers. They are designed for 525 lb. pressure and 825 deg. total steam temperature and have a normal output of 160,000 lb. per hr. and a maximum capacity of 200,000 lb. per hr. Each unit has a heating surface of 19,836 sq. ft. They are equipped with interdeck convection superheaters of the return bend type, designed to heat the boiler output to a temperature of 825 deg.

As will be noted the boilers have a tapered gas pass to allow for the natural contraction of the gases as the temperature decreases.

Naturally, boilers of this design can be expected to have a low draft loss, for there are no baffles and the

flow of gases from the furnace to the stack is absolutely straight and vertical. The total draft loss from furnace to stack (and this includes the air heat absorbing element) it is expected will be only 2 in. This makes possible a material decrease in the fan power for a given steaming capacity as compared with the conventional boiler arrangement.

Induced draft is provided by 2 induced draft fans incorporated directly in the base of each stack which are of the venturi type. These fans are designed to handle a maximum of 84,600 cu. ft. of air per minute at a temperature of 325 deg. F. against 3.5 in. static pressure. The stacks are 60 ft. high above the roof.

One fan is normally started and carries the draft for the boiler under the control of the furnace regulator, up to about three quarters of its maximum r.p.m. at which time the second fan automatically comes in and the two fans running in parallel are restored to a position obtaining the necessary draft after which the two fans accelerate simultaneously to the maximum rating of the boiler. In taking the fans off, the reverse practice is followed.

The boiler expansion is entirely upward, expansion joints being provided between the tops of the boilers and the heat absorbing element of the air heating system.

Centralized Control of Steam and Electric Generation

As stated previously, all control is centralized at one point. The combustion control system used is similar to that at the South Amboy station. It is a semi-manual arrangement in which all coal and air going to the mills and burners is premeasured, the exact amount of each being indicated on instruments in the main control room. On the boiler control board, various meters show the proper amounts of coal and air for various steam outputs of the boilers. By manual adjustment of fan speeds, mill feeder speeds and diphenyl oxide pumps, the operator can keep the pointers of all the meters at certain values that are known to be correct for a given boiler output. These values have all been predetermined and the operator merely sets a guide line in accordance with the load on the boilers and brings the instrument pointers into coincidence with this guide line. In this manner, the best combustion efficiency is obtained under all loads.

The equipment for effecting this control is all mounted on a special control board built in the form of the conventional bench board used for electrical control. This board is one of the outstanding features of the station, not only because of its location opposite the main electrical control board but also because of its design. It is shown at the right in Fig. 1, but the layout can best be understood from the close-up photograph in Fig. 7 which shows the control arrangement for one unit. As will be noted, the entire piping system is shown in schematic form, with the push buttons and indicating lamps for the various motor controls and valves in the proper locations. At the left is shown the combustion control for the boiler; the three combustion systems associated with each boiler being shown below the boiler drum and the induced draft fan and damper control above.

At the right is shown the turbine and the extraction heating system. In the case of the boiler control, the various fan and mill motors are controlled directly from the panel but in the case of turbine auxiliaries, the operation of the motors is indicated only, the actual control being effected from stations at the machines themselves. This holds true also for the valves in the system—their position (open or closed) is indicated on the board by means of lamps but their normal operation is by hand from the respective stations. In emergency, however, a number of valves are arranged so that they may be closed from this board—these being the valves in the main steam lines to the turbines and those valves provided for the purpose of isolating one part of the steam header system from another.

In short, by observing this board, the operator obtains a picture of the whole system and knows positively which valves are open or closed and which motors are operating. Together with the measuring instruments located on the upper vertical section of the panel, this forms perhaps the most comprehensive and compact boiler control board yet designed. All instrument readings are transmitted by the Selsyn system of remote indication.

On a separate panel placed at right angles to the combustion control board, are mounted the necessary steam and water flow meters, temperature and pressure gages, and the remote water columns.

Directly opposite the combustion control benchboard is the main electrical control board. All power generated in the station with the exception of that used for station power is stepped up to 66,000 v. and sent out over transmission lines at that voltage. There is no low tension switching and all the high tension switching is done at the outdoor switching station adjacent to the plant. Thus, the main control board is quite simple. It is of standard construction, using the new miniature type instruments. An interesting feature is the design of the control knobs. These are of various shapes, some round, some egg shaped, others round or oblong with knurled or serrated edges, at first glance a rather haphazard arrangement with little semblance of order, but this can be overlooked when the purpose is made clear. These handles were designed in this fashion so that the operator may know from the "feel" of a switch just what type of switch it is. Thus he will not mistake the main generator switch for a bus tie switch or a field switch or a rheostat control.

All the controls on the electrical board are equipped with Yale locks. To close a switch, the operator first has to obtain the correct key for that switch from a rack and insert it into the proper control knob. Even with these safeguards, if in a moment of absent-mindedness he should have taken the wrong key and inserted it into the wrong control, he still would have an opportunity to discover his mistake by the "feel" of the control knob. It is as "foolproof" an arrangement as it is possible to devise.

The control room in which all of this equipment is located is in the center of the station on the same level as the turbine room floor. No dividing walls separate this room from the boiler and turbine rooms; on one side the operator's vision is over the electrical board into the turbine room while on the other, over the boiler control board, he looks out into the boiler room. Both major divisions of the plant, therefore, are under his

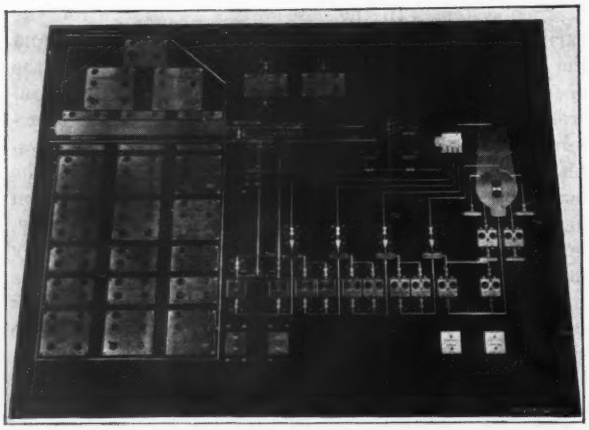


FIG. 7. CLOSE UP OF ONE OF THE COMBUSTION CONTROL PANELS

direct observation and he is instantly aware of any unusual occurrence.

Tandem Compound 15,000-Kw., 3600-R.P.M. Turbine Units

The two 15,000-kw. turbo-generators which constitute the present generating equipment are the first units of this kind to be constructed and present several interesting features. Each machine is rated at 15,000-kw., 80 per cent power factor and is designed for operation at 13,800 v., 3-phase, 60 cycles with operation at 3600 r.p.m. Direct-connected exciters of 90-kw. capacity furnish field current at 250 v. Voltage of the main units is maintained constant by automatic voltage regulators. The generators are of modern structural steel construction, with improved radial ventilation provided by internal fans mounted on each end of the rotors.

The turbines are of the tandem compound type made up of a single-flow, impulse-reaction, high-pressure turbine coupled to a double-flow, reaction, low-pressure turbine with a single-cylinder bottom exhaust opening, the high and low-pressure elements being connected for steam flow by a large overhead receiver pipe. The double flow design for the low-pressure element results in a reduction in the low-pressure blade speeds. For the present the units will operate at 450 lb. gage pressure, 750 deg. F. total temperature at the throttle and with a 29-in. vacuum at the exhaust, but provisions have been made for future operation with a temperature of 825 deg. at the throttle. The tandem compound arrangement lends itself particularly well to such an increase as this is confined only to the high-pressure element. There are 15 stages in the high-pressure element and eight stages in the low-pressure. The high pressure exhausts into the low-pressure unit at about 24 lb. absolute. The machine is provided with three admission valves, providing for high efficiency at variable loads.

Steam is extracted from four bleeder openings in each machine for heating the feedwater to approximately 400 deg. F. when operating at full load. No atmospheric relief valves are installed, a vacuum trip apparatus being substituted with a rupturing diaphragm to protect the machine in case of failure of the vacuum trip apparatus. Separate centrifugal oil purifiers are provided for each unit.

These units mark a distinct advance in the trend towards higher speeds for large central station turbine generator units in that they are the largest 3600-r.p.m. condensing type units built in this country thus far. Heretofore, the speed limit for the same capacity has been 1800 r.p.m. and complete expansion has been secured in single-cylinder turbines. The 3600-r.p.m. tandem-compound unit has distinct advantages in operating characteristics, efficiency and weight.

The turbines are served by single pass radial flow surface condensers, each having an effective tube area of 13,000 sq. ft. The water boxes are divided vertically so that one side of the condenser may be cleaned while the other side remains in service. The condensers are rigidly bolted to the turbine exhaust flanges through a cast iron connection piece and the weight in excess of that which can be suspended from the turbine exhaust flange is carried by spring supports. The tubes are expanded into both tube sheets, expansion being provided for by the use of a floating type of tube sheet on the discharge end. Each condenser is equipped with a 4000-gal. storage hotwell.

Removal of air and noncondensable gases is effected by means of a 3-stage, steam jet air ejector on each unit, designed to operate at 350 lb. gage steam pressure. These are fitted with separate condensers for each stage. These air ejectors it may be of interest to point out, are the only steam-driven auxiliaries in the station.

Two circulating pumps furnish cooling water to each unit, one of which will handle the load. These are of the bottom suction top discharge type, each with a capacity of 14,250 g.p.m. against a 14.7-ft. total head at 290 r.p.m. They are driven by 75-hp. motors.

The generator oil coolers and generator air cooler use river water.

Feedwater Heated in Direct Contact Rain Type Heaters

Feedwater is heated by means of four direct contact, rain type extraction heaters taking steam from four stages of each tandem compound turbine. In these heaters, the water to be heated enters the heater at the top and falls over plates with raised serrated edges and through a perforated plate in the form of rain to be heated by direct contact with the steam. The arrangement of heaters and the connections is shown in Fig. 9. As will be noted the system consists of a special multi-section condensate pump, four heaters, an evaporator,

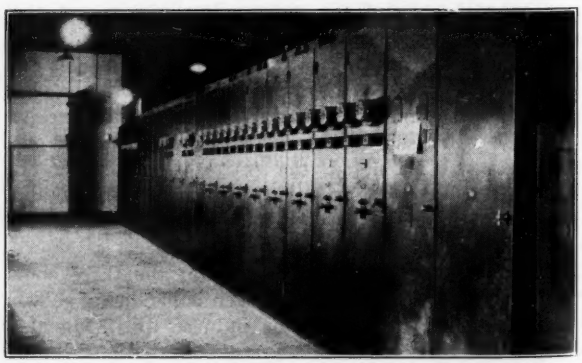


FIG. 8. THE AUXILIARY CONTROL BOARD

an evaporator condenser, a boiler feed tank and boiler feed pump. Actually there are two condensate pumps and two boiler feed pumps for each unit constituting 100 per cent reserve capacity.

Water from the condenser hot well is drawn into the first stage of the condensate pump and forced into Heater No. 1 after first passing through the air ejector. This heater is connected to the 5th stage of the low-pressure turbine and receives steam at a pressure of 4.14 lb. absolute. It is designed to heat 109,720 lb. of water per hr. from 88 deg. to 151 deg. F.

From heater No. 1 the water passes through the second stage of the condensate pump into heater No. 2 which takes steam from the high-pressure turbine exhaust (15th stage) at a pressure of 23.8 lb. absolute. This heats 119,310 lb. of water per hr. from 151 to 236 deg. F.

heaters back into the main condenser from which it is removed by the air ejectors.

Control of Steam Temperature

An extremely interesting feature of this station is the method of maintaining a constant steam temperature by means of the surface type desuperheaters. This consists of a contactor controlled through a thermostat by the temperature of the steam entering the turbine. This contactor sends out an electrical impulse to a driving mechanism on the valve whenever the steam temperature deviates from the desired normal. The driving mechanism is connected through reduction gearing to a bypass valve of the butterfly type causing more or less steam to pass through the desuperheater, depending upon whether the temperature is above or below normal. The heat liberated by the steam, in passing through the

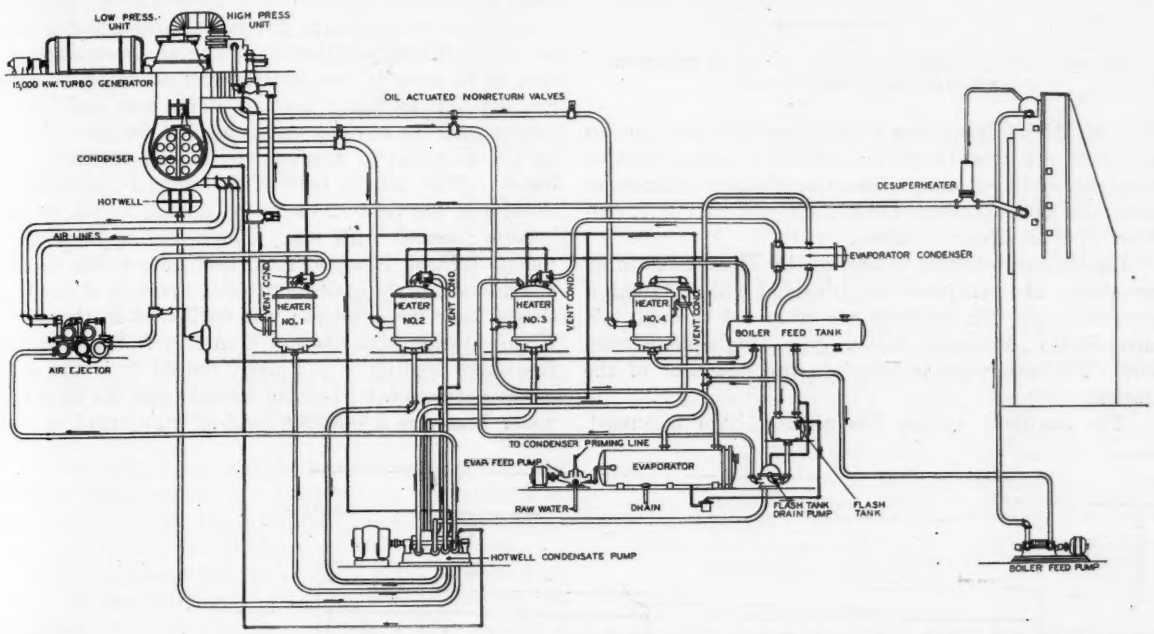


FIG. 9. FLOW DIAGRAM, SHOWING METHOD OF HEATING FEEDWATER, BY DIRECT CONTACT EXTRACTION HEATERS

From heater No. 2 water passes through the third stage of the condensate pump, through the evaporator condenser where the temperature is raised to 263 deg. into heater No. 3. This heater receives steam from the 11th stage of the high-pressure turbine at a pressure of 65.9 lb. absolute and heats 129,810 lb. of water per hour from 263 to 297 deg. F.

Finally, from heater No. 3 the water passes through the fourth stage of the condensate pump directly into heater No. 4 which receives steam from the 4th stage of the high-pressure turbine at 201.5 lb. per sq. in. absolute and heats 142,640 lb. of water per hour from 297 to 382 deg. F.

The evaporator receives steam from the 11th stage of the high-pressure turbine (the same as does heater No. 3) at about 65 lb. pressure. Vapor is condensed in the evaporator condenser and the condensate after passing through the flash tank is delivered into heater No. 3.

Each heater, it will be noted, is provided with a vent and a vent condenser and these are connected so that the air is cascaded successively through the various tubes of the desuperheater, is absorbed by the water surrounding the tubes which is connected into the boiler circulation. These desuperheaters which are installed on each main steam line to the boilers are designed to handle steam at 825 deg. F.

Electrical Distribution Is at 66 Kv.

At present all electricity generated is delivered to the transmission system of the Virginia Public Service Co. at 66 kv. but, since plans call for future operation of the system at 110 kv., all electrical equipment installed has been selected with this end in view. The 13,200-v. current delivered by the generators is stepped up to 66 kv. by two banks of single-phase, outdoor type transformers, Delta connected now, Y connected in future and rated at 6250 kv-a., 13.2/66/115 kv. The generator leads are connected solidly to the primaries of these transformers, no low voltage generator circuit breakers being provided.

All switching, therefore, is done on the "high" side.

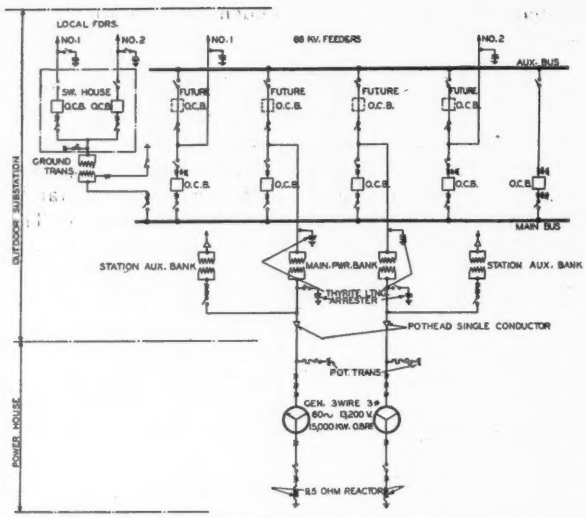


FIG. 10. SINGLE LINE DIAGRAM OF HIGH TENSION ELECTRICAL CONNECTIONS

Two 66/115-kv. buses, one a main bus and the other an auxiliary, are provided in the outdoor switching station adjacent to the station. The transformer secondaries feed these buses through 138-kv., 600-amp. T.P.S.T. outdoor type, oil circuit breakers.

Lightning protection is afforded by Thyrite lightning arresters. The generators are provided with differential protection and the neutrals are grounded through 9.5-ohm, 7600-v., 800-amp. indoor type, single-phase reactors. The latter are installed in the basement of the station.

The auxiliary system has already been discussed. Normally all auxiliary power at 550 v. is taken from transformers connected to the main generator leads but for emergency a 1000-kw., noncondensing, spinning house, turbo-generator with direct-connected exciter is provided. Each boiler and each turbine unit is provided with a separate auxiliary bus section. The auxiliary buses and main control panels are located in a room above the main control room. Here also is located the station storage battery for switch circuits and emergency lighting.

Conclusion

In concluding this description, it is perhaps unnecessary to call attention to the fact that though this is an unusual station in the sense that it incorporates many features which are unique in power plant practice, none of these features lack justification from an engineering and economic standpoint. None of the features which make this station different from the ordinary station are of a nature which might develop unforeseen difficulties in their ultimate application. The air preheating system, to be sure, is new but the idea of using an intermediate heat exchange medium is not new and its simplicity and the obvious advantages to be derived from its use lead one to wonder why it had not been tried before. That also is true of the central control room. Surely, in the past 10 or 15 yr. during which we have become familiar with many forms and applications of remote control, it would seem that before this the idea of centralizing the entire control of a station at one point should have materialized; yet, until now in the case of Bremo station, this has not been done. Direct contact feedwater heating is not new; indeed it is the oldest method of feedwater heating we have and the open feedwater heater is a familiar piece of equipment in thou-

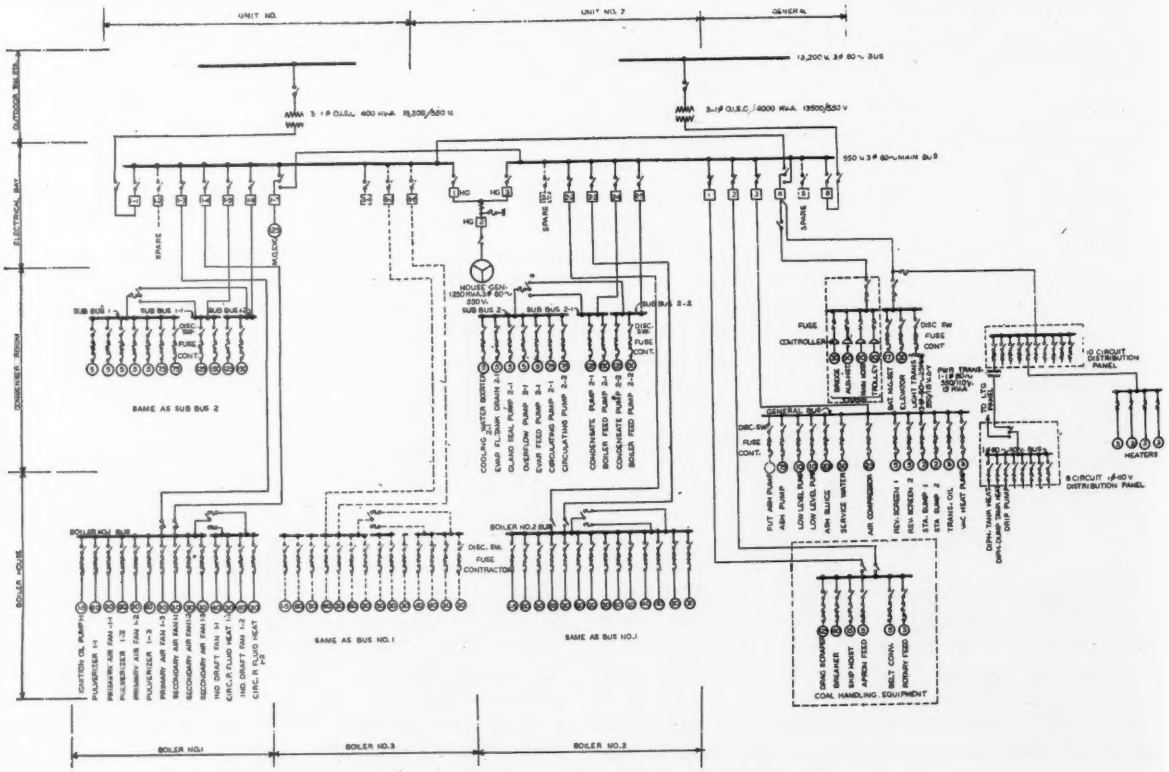


FIG. 11. THE AUXILIARY ELECTRICAL SYSTEM

sands of small industrial plants. In central stations, however, where high pressures are the rule and where the regenerative cycle of feedwater heating utilizing extraction steam from the main turbine was evolved, somehow the idea gained strength that only closed heaters were suitable for the purpose. The experience at South Amboy has served to dispel this idea and so, in Bremo again, direct contact heaters are used.

In short, Bremo was designed by engineers on an engineering basis, not just built from catalogs. It is the result of the most excellent coöperation and interchange of ideas between those designing the plant and those building the equipment. It is an outstanding power plant, the operation of which will be regarded with great interest by the entire power field.

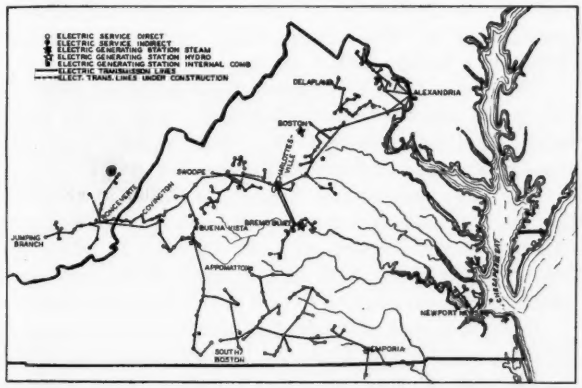


FIG. 12. A MAP SHOWING THE TERRITORY SERVED BY THE VIRGINIA PUBLIC SERVICE CO. BREMO STATION IS LOCATED AT BREMO BLUFF, ABOUT 30 MILES SOUTH OF CHARLOTTESVILLE

Bremo station was designed and constructed by the Electric Management and Engineering Corporation of New York City for the Virginia Public Service Co., an operating unit in the Middle West Utilities System.

Frank D. Chase, Inc., of Chicago, acted as consulting architects, and Sargent and Lundy, consultants for the engineers.

U. S. PATENT No. 1,786,113, recently issued to Roy O. Henszey for his deconcentration method covers withdrawal from the boiler of an amount of water carrying heavily concentrated salts in the same ratio to make-up water that concentration in make-up water bears to that in the water withdrawn, thus maintaining concentration in the boiler at a desired figure without undue waste of boiler water. Water withdrawn is utilized to heat make-up water and feedwater in two stages, thus preventing waste of heat or may be used in a single stage to heat make-up water only. By various automatic controls, the amount of water withdrawn may be regulated, according, to the amount of make-up water, according to concentration of the water withdrawn or according to final temperature of the water withdrawn, thus balancing the water flow, controlling the concentration in the boiler or regulating the heat economy of the process.

EXCESSIVE transformer temperatures cause rapid deterioration of the insulation and cause the oil to discolor and sludge.

1931 Midwest Bituminous Coal Conference, May 21 and 22

PROGRAM for the 1931 Midwest Bituminous Coal Conference, to be held May 21 and 22 at the University of Illinois, Urbana, Ill., is given below. Complete details on arrangements may be obtained from B. R. Gebhart, Illinois Coal Bureau, 307 No. Michigan Ave., Chicago, Ill., or Dr. M. M. Leighton, State Geological Survey, Urbana, Ill. Hotel reservations should be made at the Urbana-Lincoln Hotel, Urbana, or at the Inman, New Beardsley or Hamilton Hotels, Champaign. The program (as of April 1) is as follows:

THURSDAY, MAY 21

9:30 a. m.—Registration. Room 215, Electrical Engineering Laboratory.

10:30 a. m.—Inspection of Engineering Buildings and Laboratories, State Geological Survey Exhibit, Mining Engineering Laboratory.

1:00 p. m.—Value of Midwestern Coal. Room 215, Electrical Engineering Laboratory.

1. Methods of Determining the Relative Value of Coals. Including discussion of (a) sampling and analysis of coals, and (b) utilization of coals. By W. D. Langtry, President, Commercial Testing and Engineering Co., Chicago.
2. To What Extent Have Midwest Coals Met Competitive Demands for Better Preparation? By John A. Garcia and H. C. Cooley, Allen and Garcia Co., Chicago.
3. Comparative Heating Value of Fuels in the Research Residence. By A. C. Willard, Professor, Heating and Ventilation, and Head of Department of Mechanical Engineering, University of Illinois, Urbana.
4. Paper on Economics and Utilization of Natural Gas in Relation to Midwest Coal.

4:00 p. m.—Baseball—University of Illinois vs. Purdue University. Tickets on sale at stadium.

6:15 p. m.—Informal Dinner Session—Union Arcade.

1. What Does the Future Hold for Midwest Coal? By S. W. Parr, Professor of Applied Chemistry, Emeritus, University of Illinois, Urbana.
2. The Coal Research Program of the State Geological Survey. By M. M. Leighton, Chief, Illinois State Geological Survey, Urbana.
3. Space Requirements for Coal Burning Plants. By an architect designated by the Chicago Chapter, A.I.A.
4. Greetings and Introduction of Committee of Ten Representatives. By C. B. Huntress, Executive Secretary, National Coal Association, Washington, D. C.
5. The Committee of Ten, Its Activities and Purposes. By Oliver J. Grimes, Managing Director, Committee of Ten, Coal and Heating Industries, Chicago.

FRIDAY, MAY 22

9:30 a. m.—Domestic Utilization. Room 215, Electrical Engineering Laboratory.

1. Recommended Setting Heights for Heating Boilers Equipped with Mechanical Stokers. By E. L. Beckwith, Chairman, Engineering Committee, and Past President, Midwest Stoker Association, Chicago. Discussion committee consisting of T. A. Marsh, J. H. Walter and Joseph Harrington.
2. Operating Tests of Stokers in Service.
   (a) From the Chicago Coal Merchants Association, comparing coal and oil at the St. Clair and Eastgate hotels in Chicago.
   (b) From the Commercial Testing and Engineering Co. on tests made in the model set-up at the Coliseum during the 1931 Power Show.
3. Burning Area Requirements as Established by Actual Boiler Tests. Representative of Kewanee Boiler Corp.
4. A Study of Small Stokers for Semi-Industrial and Plant Uses. By G. A. Young, Professor and Head, and W. T. Miller, Instructor, School of Mechanical Engineering, Purdue University, Lafayette, Ind.

1:30 p. m.—Industrial Utilization. Room 215, Electrical Engineering Laboratory.

1. Adapting the Power Plant to Local Coals. By Lisle A. Pierson, Vice-President, N.A.P.E., Detroit.
2. A paper on Pulverized Coal.
3. Midwest Coal Combustion Tests.
   (a) Results at the University of Illinois. By A. P. Kratz, Research Professor, Department of Mechanical Engineering, University of Illinois, Urbana.
   (b) Results at Purdue University. By A. A. Potter, Dean of Engineering and Director, Engineering Experiment Station, Purdue University, Lafayette, Indiana.
4. Training of Plant Operators to Use Illinois and Indiana Coals. By A. W. Cole, Professor of Steam Engineering, Purdue University, Lafayette, Ind.

Adjournment.

Cost of Refrigeration in Oil Refinery*

By J. M. Wadsworth

REMOVAL OF THE WAX CONTENT of lubricating oil by means of refrigeration is an important step in refinery design. The oil may be refrigerated by calcium chloride brine circulated through a brine cooler and an oil chilling tank; by the use of dewaxed oil which follows the same course and answers the same purpose as the calcium brine system; or by the use of anhydrous ammonia or other suitable gas expanded directly in the coils of the oil chilling tank. After cooling, the wax is removed either by cold settling, filtering or centrifuging.

OPERATING REFRIGERATION COST FOR A 100 BBL. PER HR. DEWAXING PLANT

Item	Cost per ton of Refrigeration
Operating labor	$0.1378
Water	0.0487
Electricity	0.3589
Lubrication	0.0080
Supplies	0.0024
Manufacturing supplies	0.0429
Repairs	0.0368
Material	0.0201
Auto	0.0018
Air	0.0039
Superintendence	0.0346
Engineering	0.0051
Steam	0.0766
Laboratory	0.0307
Storage	0.0052
Pumping	0.0130
Miscellaneous	0.0380
	$0.8645

Following the gasoline and kerosene removal from the crude oil the lubricating stock is treated with sulphuric acid and agitated until a heavy black precipitate, termed acid sludge, is formed and settled out. This sludge is about 22 per cent of the stock sustained in the treating operation. The acid oil is then mixed with a decolorizing clay pulp, heated to 425 deg. F. and the water and acid evaporated and removed by means of a jet condenser. The clay mixture, with the temperature maintained from 150 to 160 deg. F., is then pumped to a filter press where the clay is removed, the oil is then mixed with naphtha in the proportion of about 60 per cent naphtha and 40 per cent oil.

This solution passes through a heat exchanger to a blending tank where the naphtha content is increased to about 70 per cent and then to a batch chiller where the temperature of the oil is lowered from about 100 to 25 deg. F. over a period of 15 hr. The brine temperature is maintained at a temperature of 10 deg. below the oil temperature with the chilling rate held to 5 deg. F. per hr. If the oil is chilled too rapidly, the lighter waxes do not crystallize properly and the oil cannot be satisfactorily centrifuged. The naphtha is necessary in order to give the satisfactory specific gravity to allow separation of the wax.

In the particular plant designated the oil solution leaves the batch chiller at 25 deg. F. and is pumped through 8 continuous chillers at the rate of 95 to 100 bbl. per hr. Four of the eight chillers are cooled by brine and four by direct expansion. Refrigeration is provided by a two-stage compressor with clearance pockets rated 198 tons of refrigeration per 24 hr. when operating at 0 lb. suction pressure and 195 lb. head pressure. This machine is driven by a 500-hp., 2300-v. synchronous motor. Ammonia gases from the coils in the direct expansion chillers at a vacuum of 20 in. is delivered to the suction of the main compressor at 0 lb. pressure by a 60-t., single-stage booster compressor driven by a 50-hp., 2300-v. motor.

The brine tank is maintained at a temperature of 115 to 120 deg. (—15 to —20 deg. F.) part of the brine being circulated through the batch chiller and part through the four continuous chillers.

The oil enters the first continuous chiller at about 25 deg. F. and is cooled in steps of from 8 to 11 deg. per chiller to a temperature of —47 deg. F. It leaves the centrifuge at about —35 deg. F. and passes through a series of heat exchangers to cool the incoming oil supply.

Operating cost of a plant of this type based on 1 t. of refrigeration are given in the accompanying table.

The cost of material and erection of such a plant, (where the continuous chillers have a capacity of from 95 to 100 bbl. per hr.) including the refrigeration unit with continuous cylinders, water condensers and cooling equipment with interconnected piping is approximately $830 per ton.

*From an article, Refrigeration in Oil Refining, appearing in Refrigerating Engineering, the journal of the A.S.R.E.

Commercial Standards for Fuel Oil

Specifications for Industrial Grades of Fuel Oil covered by Commercial Standard CS 12-29 issued by the Bureau of Standards fixes the maximum viscosity for the three grades of oil. On page 404 of the April 1, 1931 issue the maximum viscosity of No. 4 light industrial fuel oil was given as 125 sec. Saybolt Universal at 122 deg. F. This maximum viscosity should be 125 sec. at 100 deg. F. Viscosities for grades 4 and 6 are correct, that is, 100 and 300 sec. Saybolt Furol respectively, at 122 deg. F.

According to a recent report from the Bureau of the Census, Department of Commerce, Washington, D. C., the estimated tonnage of fabricated structural steel for February, 1931, is 159,200 t. which is 39.8 per cent of the capacity. For February, 1930, the tonnage was 267,600 or 66.9 per cent of the capacity, while for February, 1929, the tonnage was 250,635 or 65.1 per cent of the capacity. Total tonnage of fabricated structural steel for 1930 was estimated by the report as 2,689,600 or 56 per cent of the capacity. The foregoing figures are the bookings.

Shipments of fabricated structural steel for February, 1931, reached a total of 166,800 t. or 41.7 per cent of the capacity as compared with 280,400 t. or 70.1 per cent of the capacity in February, 1930.

STEAM ENGINES for INDUSTRIAL SERVICE

High Back Pressure and Bleeder Engines Offer Advantages for Special Conditions. In cases where the steam load is almost constant and the power load variable, a back pressure control valve will be found advantageous

HIGH OVERALL EFFICIENCY within a wide load range and operating conditions and its adaptability to changing requirements of service make the reciprocating steam engine a popular type of prime mover, especially in the smaller sizes. In general, the majority of engines built today are of the noncondensing type

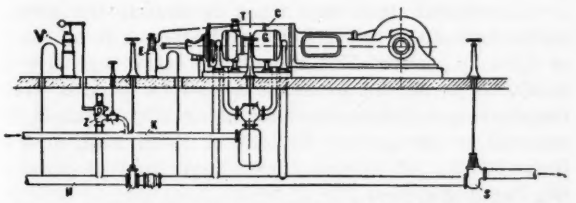


FIG. 1. ARRANGEMENT OF PIPING AND VALVES IN A BACK PRESSURE ENGINE INSTALLATION

with the exhaust steam used for heating or process work. To meet necessary process requirements, back pressures range all the way from 1 or 2 lb. up to 150 lb. ga. The former figures are, of course, the usual practice for noncondensing engines and the latter figure rare. Pressures of from 10 to 50 or even 75 lb. may, however, be considered common.

Many of these back pressure engines are of the single-cylinder type and require no special back pressure regulator, the engine being governed by the usual speed governor in accordance with the power or electrical load. Excess steam above the process requirements is exhausted to the atmosphere usually through a spring or lever loaded atmospheric relief valve and any deficiency made up by live steam through a reducing valve actuated by the pressure in the low-pressure main.

In some cases, however, the steam load is almost constant while the power load is variable. If the steam load is considerable and the power load cannot be rearranged to agree with the steam load, it is desirable to replace the usual speed governor with a back pressure control valve. This method is desirable where the power load can be arranged to absorb the fluctuation over short peaks or where the power load is large enough so that the steam engine can be coupled electrically or mechanically in parallel with other sources of power which will keep the engine in step and supply the balance.

In order to maintain a flexible arrangement, it is desirable to have the governor arranged so that either type of governing, i.e., speed or constant back pressure may be maintained. Equipment for accomplishing this is shown by Figs. 1 and 2. In normal speed governing, steam from the boiler passes through pipe K to the engine cylinder C where it is expanded and passes out to process through exhaust pipe H. Excess pressure above that desired in H is relieved through the spring load atmospheric relief valve S and any deficiency of pressure is made up with live steam through Z.

Figure 2 shows the arrangement of the layshaft with eccentrics, speed adjusting device and governor for constant speed. The sheaves of eccentrics A (cutoff eccentrics) which operate the steam inlet valves, ride on eccentric bushings B (main eccentrics) keyed to the shaft and controlled by the shaft-governor R. In this mechanism an oil pressure operated servo-motor C, rotating with the layshaft, is inserted to transmit the movement of the governor flyweights to the cutoff eccentrics.

This cylinder C is sub-divided into four chambers by a wing piston E keyed on to the shaft and two internal

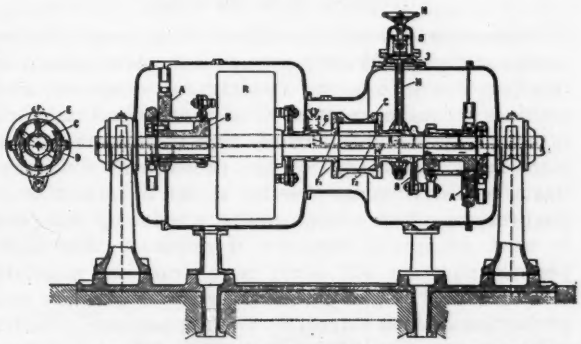


FIG. 2. AN OIL PRESSURE GOVERNOR FOR CONSTANT SPEED OR CONSTANT PRESSURE REGULATION

bosses D extending to the hub of the wing piston, as shown in the small section. Each two diametrically opposite chambers are interconnected by oil passages F_1 and F_2, forming two distinct oil systems. The oil pressure in the chambers connected to passage F_1 is kept constant by the spring loaded relief valve G revolving with the layshaft, whereas passages F_2 connecting the other two chambers lead through a stationary connection H to a spring loaded overflow valve J fitted to the governor casing.

Both oil systems are fed with oil from the forced lubricating pump through a central port in the layshaft and radial drillings L and K. Normally, the springs of the two valves G and J are so adjusted that the oil pressure in all four chambers of the cylinder is equal, the device then merely acts as an oil brake or buffer to any displacements of the governor. By turning the

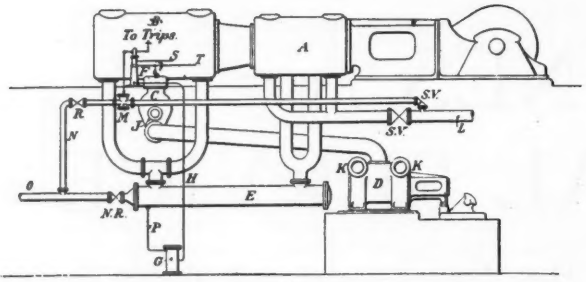


FIG. 3. ARRANGEMENT FOR BLEEDING AT CONSTANT PRESSURE FROM A COMPOUND ENGINE

handwheel N, the tension on spring O is changed and the equilibrium of the oil pressure in the two systems upset. This causes the cutoff eccentrics A to turn, forcing them to take up a new position, corresponding to an altered cutoff and output. The device is so designed that any increase of oil pressure under valve disc J causes a reduction of the cutoff.

To adapt the mechanism so as to maintain constant pressure in the exhaust pipe H, the cutoff is varied by a modified speed adjusting device T of the speed governor G wheel is actuated by E of Fig. 1. Oil pressure under valve J, Fig. 2, is controlled by the transmitter E of Fig. 1. The mechanism is fitted with a three-way cock which enables the engine either to maintain constant speed or constant exhaust pressure. In the latter case, the pressure actuated transmitter E takes the place of the manually operated handwheel N.

Bleeding from Receivers

Increasing demands for larger units, more flexible units and higher efficiency prompted the development of bleeding steam from the receivers of compound and multiple expansion engines. This is an old scheme used in cotton mills and quadruple expansion pumping engines many years ago. If the pressure at which the steam is bled from the receiver is not important or if the pressure is high enough so that a reducing valve can be used, no special regulator is required. The high-pressure governor will admit more steam and maintain constant speed but of course the receiver pressure and proportion of load carried by the low-pressure cylinder will vary according to the percentage of the total steam bled from the receiver. At low loads the work may be performed entirely by the high-pressure side.

If the steam is required at a fixed pressure, it is necessary to place the low-pressure cutoff under the control of a low-pressure regulator, the speed of the engine still being controlled by the high-pressure speed governor. An arrangement for maintaining fixed receiver pressure on a 1250-hp. tandem compound engine with a unaflow low-pressure cylinder is shown by Fig. 3. The engine, 28 and 41 by 36 in., is designed for 160 lb., 550 deg. F. steam and a receiver pressure of 60 lb.

Arrangement of the unit is as shown in Fig. 3. Steam is carried to the high-pressure cylinder by a pipe, exhausts to the receiver and part is taken to the mill system through a nonreturn valve, N.R., the remainder passing through to the low-pressure cylinder to the condenser, C. When mill demand is large and engine load is light, live steam is taken through a bypass pipe, regulator M and reducing valve R direct to the mill system. Position of regulator M is varied by the relay F according to receiver pressure and the relay also acts to vary the low-pressure cutoff so as to maintain 60 lb. in receiver E. Speed of the engine is regulated by a governor which controls high-pressure cutoff.

Admission valves for both cylinders are of double-ported piston type, raised by latches driven by links from a lay shaft and, when tripped by knock-off rollers, are closed by springs. For the high-pressure cylinder, position of the trip shaft, which controls the knock-off rollers, as determined by the governor; for the low-pressure, by the relay F according to receiver pressure. From the receiver, a small pipe P, Fig. 3, transmits pressure to the oil chamber G, whence it is led to relay F. The oil piston is coupled by linkage to the trip shaft, also to a lever which has a spring and weight working in opposition. The weight can be moved along the lever to vary the receiver pressure over a considerable range.

Guaranteed steam rate when developing the normal rating 1235 hp., was 11.17 lb. per b.hp-hr. At overloads of 1350 hp., it was 11.2 and at 920 hp. it was 11.6 lb. If 15,000 lb. per hr. of steam is bled for process work, the steam per horsepower-hour above that required for the mill system is only 6.22 lb. at rated load, or 4.92 lb. at 920 hp., showing the advantage from adoption of the bleeding system.

Regulator Details

A regulator for the service, that is to accomplish the function of relay F, Fig. 3, is shown by Fig. 4. Close regulation is possible but in normal operation a pressure variation of within ½ to 1 lb. is sufficient. Construction of the regulator is shown by the section.

Pipe A conducts steam from the process-steam main through a strainer T and valve S to the interior of a closed cast-iron chamber C. Steam to the chamber is controlled by a valve B, held close by an adjustable spring D. The tension of the spring is so regulated that at the pressure desired in the main there is a slight escape of steam past the valve B, this steam emerging

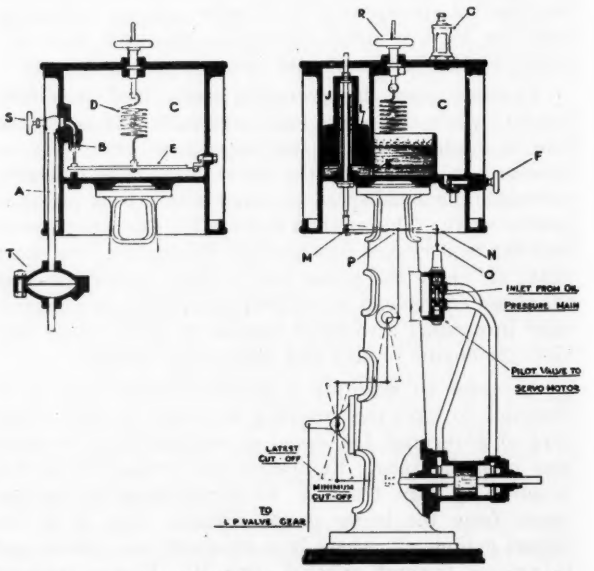


FIG. 4. A REGULATOR FOR MAINTAINING CONSTANT RECEIVER PRESSURE

from the chamber C through an adjustable leak F to atmosphere.

Rod E controlling the valve B is of stainless steel and the right-hand end is finished to a thin strip, which is secured to a lug and bends slightly as the rod moves. The end supporting the valve has a cup engaging the rounded end of the valve spindle. The whole mechanism is practically frictionless. Steam escaping from the valve B fills the chamber C at a pressure slightly above atmospheric owing to the throttling effect of the leak F. Any variation in pressure in the main will result in a corresponding change in the pressure inside the chamber. It is this latter variation which is made use of to operate the regulating mechanism.

In the chamber is a container H filled with mercury, which communicates through a hole K with a chamber J sealed off from the steam and vented to atmosphere. In this chamber rides a cast-iron float L, frictionlessly located by fins on a central tube. A variation in the pressure in the chamber C will act on the surface of the mercury in container H and cause the float L to rise or fall. This movement is communicated through a lever M N to a pilot-valve, operating an oil servo-motor, shown towards the bottom of the section. The pilot-valve is of the type normally used in steam turbine governors. A rise of the float L will push the pilot-valve down, causing the servo-motor to be moved to the left; this movement will, however, raise the lever M N by the pin P, and restore the pilot-valve to its normal position. There is thus a definite position of the servo-motor for any given pressure in the chamber C. The servo-motor in turn controls the cutoff to the low-pressure cylinder.

Under some conditions, the demand for heating steam exceeds that available from the engine at the power at which it is called upon to work at the moment and it becomes necessary to supplement the supply from the high-pressure main through a reducing valve. The regulator will also control this additional supply.

Many Schemes for Bleeding Proposed

Various other devices have been suggested or utilized for bleeding steam from an engine. The earliest plan was to operate one end of the cylinder condensing and the other noncondensing. This was reasonably satisfactory but has two disadvantages: the bled steam was a fixed percentage of the total flow to the engine; and at low loads the bled steam was insufficient, making it necessary to use live steam while exhaust steam was wasted to the condenser by the condensing side; on heavy loads, it was necessary to waste bleed steam through a relief valve.

A third method suggested but apparently never used commercially was to place a valve in the exhaust line, this valve to remain open to the process line until the pressure dropped below the desired value. The valve then opened into another line and directed the remainder of the steam to the condenser. At low loads, the terminal pressure would be very low and the use of this would be limited to long cutoffs.

A fourth method proposed by Prof. Stumpf, but as far as is known never used, was to place extraction ports along the cylinder of a Unaflow engine through which steam would pass in the interval between uncovering the ports by the piston and the line when the cylinder and process pressures were equalized. Steam would be bled during both expansion and compression.

Selector Valve Used to Cut Cylinders Over

Still another method has been used in connection with a Chuse vertical multicylinder uniflow engine. This consists of an oil operated valve mechanism which is actuated by the process main pressure. Exhaust steam from one or several of the cylinders may be utilized for process work and heating while the balance of the cylinders exhaust into a condenser. The cylinders are automatically opened to the process main as the steam demand increases and are closed as the steam demand decreases.

This selective exhaust mechanism consists essentially, of a piston valve as shown in Fig. 5, controlling the exhaust of each cylinder and means for controlling the positions of the valves. Three of these valves are combined in one housing, which is bolted to the cylinder block. The valves are shifted by means of oil pressure, and a double-acting cylinder, with a differential piston is provided for this purpose. The oil is controlled by a pilot-valve mechanism, which in turn is under control of the pressure in the back-pressure system.

Assuming a valve to be in condensing position, as shown on the drawing and assuming that the pressure in the back-pressure system drops a slight amount, the pilot valve will be moved so as to admit pressure oil to the lower part of the oil cylinder as well as to the two clearance valves of the corresponding steam cylinder. All three valves will move simultaneously and switch the steam cylinder over from condensing to back-pressure operation. The pilot valves are tuned so they respond to very slight differences of pressure and while the total pressure change in the back-pressure system to cover the movement of all six valves is not more than 1 lb. per sq. in., the change in oil pressure which moves the pilot valves is from 10 to 60 lb. In this way it is possible to produce a very positive step-by-step control for shifting the valves comes from the same source that supplies the camshaft control, therefore no additional mechanism is needed.

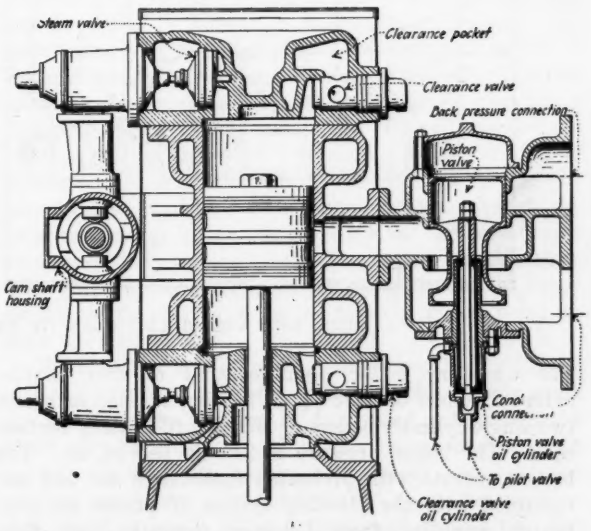


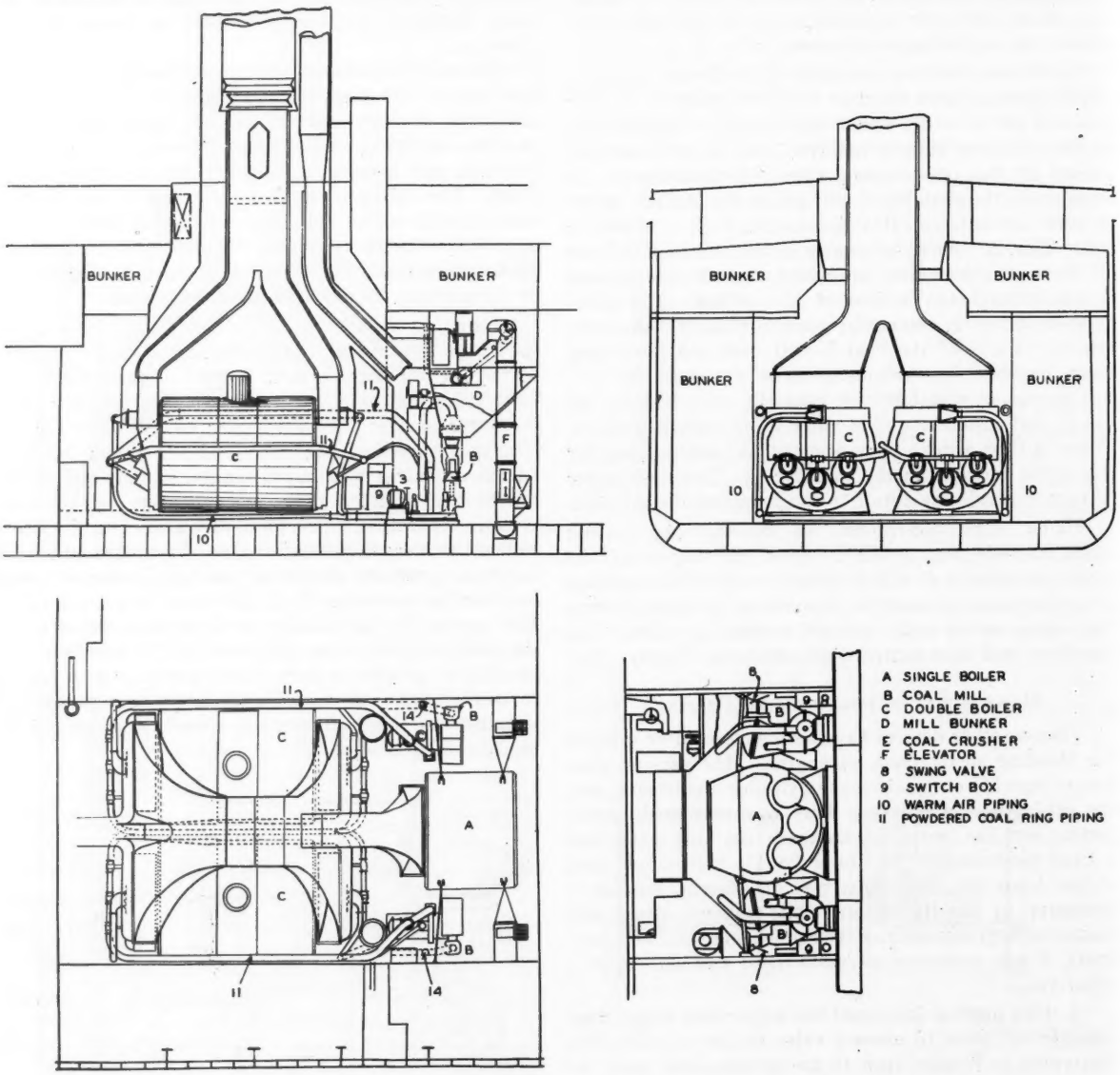
FIG. 5. VERTICAL UNIFLOW WITH MECHANISM FOR BLEEDER OPERATION

Powdered Coal for Ships

SYSTEM FOR S.S. STASSFURT OF HAMBURG AMERICAN LINE. BY DR. ING. EMIL GOOS

EACH OF EIGHT ships, of which the steamer Stassfurt is one, is equipped with a turbine unit with accessory condenser, transmission and auxiliary machines, which, at a speed of 110 r.p.m., delivers 6200 hp.

Because of the increased air resistance due to the new air preheater system, an induced draft fan has been provided in the stack, which was supplied by W. Schmidt, Cassel. It has to create such a partial vacuum



SIDE, END VIEWS AND PLAN OF STASSFURT S. S. POWDERED COAL PLANT

The accessory boiler plant consists of two double-cylinder boilers of 5382 sq. ft. heating surface each and two single-cylinder boilers of 1691 sq. ft. heating surface each. The boiler pressure is 213 lb. per sq. in. The boilers operate with preheated combustion air and are equipped with the Howden system of pocket air preheater, supplied from Glasgow through Rud. Otto Meyer, Hamburg.

that in the furnace itself the partial vacuum is maintained at from a little under zero to about minus 0.02 in. water; never should there be an air pressure in the furnace.

Three systems of powdered coal firing have come predominantly into use on American and British ships, namely the system of the Todd Shipyard Corp. of New York, the system of Clarke Chapman, Glasgow, and the

system of Brand, London. These three systems are differentiated from each other mostly by the arrangement and the design of the pulverizing plant with the pipe lines. The Todd system employs for each burner a special mill with accessory pipe line. In the Clarke Chapman system one mill, by means of a common pipe line, serves from three to a maximum of six burners. In these two systems no special powdered coal bunker is used, as the powdered coal is supplied from the mill direct to the burners. The Brand system employs a coal bunker with a single mill, the individual burners being supplied with powdered coal from this bunker by means of special equipment. The powdered coal bunker is of such size that coal can be burned from it for several hours, in case the mill should be in trouble so that, during the time available, either a reserve mill can be started or the disturbance can be eliminated.

After exhaustive consideration, the Hamburg-American Line chose the Clarke Chapman system, since its arrangement of mills promised safer operation of the pipe line system and the plant is not too complicated. In addition, this system had up to that time found the greatest application and meanwhile the A.E.G. in Berlin (General Electric Co.) had acquired the license for the building of these installations, so that the Hamburg-American Line could order the plant in Germany. The arrangement of the installation is shown in the illustration.

In order to obtain space for the mills, burners and uptakes, without having to sacrifice storage space on board, one of the two single boilers was omitted on the Stassfurt, the remaining boiler shifted to midship and the powdered fuel equipment set up on both sides of this boiler. The arrangement is such that for each double boiler C one mill B with accessories has been erected, from which, by way of a circuit pipe line, 11, the powdered coal is supplied in the customary manner to the burners.

Drying of the coal is effected by hot air, for which purpose in the pocket air preheater, a special duct equipment with regulation has been provided, so that, depending on the moisture content of the coal, more or less highly preheated air can be drawn through the mill. By means of this air, which is drawn in through a special fan coupled to the mill, the screening of the powdered coal and its further conveyance, to the burners, is effected.

Above each mill is a coal bunker, D, over which a crusher E is installed, which is filled by means of a special elevator conveyor, F. The crusher sizes the coal to about fist-size. There is, however, a screen between the crusher and the coal bunker, by means of which lump coal is retained for the operation of the hand-fired single boiler. This hand-fired boiler has a special stack and partial pressure blower, so that the furnace plant, including stack, is quite independent of that for the two double boilers.

Since each mill supplies six burners, corresponding to the six furnaces of each double boiler, special care had to be taken in the arrangement of the pipe system, so that each burner would receive the same exactly-determined quantity of powdered coal. The pipe was, therefore, installed, as far as possible, with long radius bends. Branching to each individual burner is effected by a one-way cock of special design, which can be adjusted for any quantity of powdered coal. The design of this cock is such that the main flow is passed around the housing of the cock, which can be set in the correct position by means of a clutch lever.

In case too much powdered coal is supplied to the pipe line, the surplus is returned to the mill by way of the ring pipe section.

The hearth, which replaces the grate for hand firing, was designed and supplied by the A.E.G., the lining of the furnace and combustion chamber being limited to a minimum. Determining the size of the brick work was the fact that the powdered coal ignites and burns satisfactorily even with a content of only 19 per cent of volatile particles. Furthermore, the combustion gases must be well mixed in the combustion chamber, yet the combustion in the adjoining furnaces must not be interfered with.

Due to this lining, the heat conduction from the furnace is, of course, influenced unfavorably. The hot gases enter, therefore, with comparatively high temperature into the combustion chamber so that the nuts of the staybolts, as is customary also in oil firing, have to be protected against burning by means of special caps. Likewise, the riveted seam between the furnace and the head is protected by a special ring of high refractory material.

This powdered coal plant has operated satisfactorily except for a few minor disturbances, which, however, can later be avoided by the personnel becoming gradually familiar with the peculiarities of the system. As to the economy of the plant, conclusive judgment can be formed only after completion of several trips. For the present, the powdered coal plant is installed upon this ship as experimental, with the intention to facilitate the difficult work of the firemen, especially in the tropics. If the installation proves safe in operation on long trips, the powdered coal firing system will find introduction increasing on new ships for trips to the tropics, if only for humane reasons.

NEW TYPE of stroboscope, a scientific device for stopping motion to study the behavior of machines operating at high speed, has been developed in the department of electrical engineering at the Massachusetts Institute of Technology, Cambridge, Mass. The new stroboscope was developed by Harold E. Edgerton, a member of the instructing and research staff. The unique feature of Technology's stroboscope is the electrical circuit which causes a condenser to discharge periodically through a thryatron mercury arc tube. An intense blue actinic light of extremely short duration, precisely timed to correspond with the speed of the machine under observation, is produced by a large current through the tube and makes it possible to adapt the stroboscope for photographic as well as visual observation. In the study of a synchronous motor, for example, the flashes occur as the north and south poles reach a given point in their whirling course.

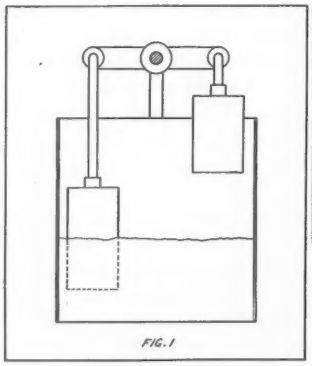
So effective is the new stroboscope that still and motion pictures of a 160-hp. motor have been made while the machine was running at full speed. Although the rotor was turning over at a rate corresponding to a ground speed of 95 mi. an hour, every detail of the moving parts was shown as clearly as if the machine was standing still. Thus it was possible to study the characteristics of the machine from the moment the power was applied until it reached full speed.

Floats Should Float

Requirements for Buoyancy and Lifting Power

*By J. Rowland Brown**

PROPERLY DESIGNED, made and tested and used under the conditions for which it was designed, there is no more dependable and reliable device than a float. Unlike many other devices, a float must be 100 per cent perfect. There is no degree of goodness; it is either good or no good. When it fails to meet a test, a float is seldom salvaged; it is nearly always scrapped, therefore, it must be made right.



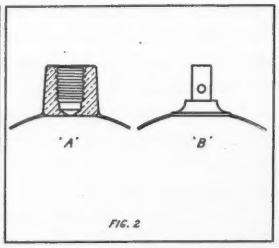


FIG. 1. BUOYANCY OF BALANCED FLOAT
FIG. 2. SPUD FORMS FOR FLOAT CONNECTION TO MECHANISM

Because of the demand for buoyancy, which means light weight, floats generally operate at a low factor of safety so that they must be made with great care and uniformity. The successful float manufacturer recognizes these factors, the result being a highly developed and specialized industry, which is meeting the requirements placed on it as to pressure and temperature. Nevertheless, as for many other devices, floats have too often been produced without sufficient thought as to their design or requirements.

Principle of Buoyancy

The principle of Archimedes may be thus stated: When a body is either wholly or partially immersed in a fluid, it suffers a loss of weight which is equal to the weight of the fluid that has been displaced. The result is an upward force which may be assumed to act at the center of the mass of the fluid displaced, whatever the form of the immersed body.

When the weight of a body submerged in a liquid is greater than that of an equal volume of the liquid, the body will sink. If the submerged body weighs the same as an equal volume of the liquid, the body will remain in equilibrium in any part of the liquid. A body of weight less than that of an equal volume of the liquid will rise to the surface and float partly submerged. Such a body may be used as a float.

By the weight of the body its effective weight is understood. For example, Fig. 1 shows a float which in itself weighs more than an equal volume of the liquid but it is counterbalanced so that its effective weight is only one half that of an equal volume of liquid, therefore, it floats only half submerged. The difference between the weight of the float and the weight of an equal volume of the liquid is the buoyancy, in other words, the upward force exerted upon the float when fully submerged. To put it another way, it is the force required to push the float under the surface.

Float Service

In some devices, a float is used only as an indicator of level and as such all it need do is float. But in most devices it is called upon to exert a force upward by its buoyancy or downward by its weight or to act in both directions. In such cases, the weight and buoyancy are of vital importance. If the float is operating under fluid pressure or is subjected to mechanical strains, the matter of strength becomes important.

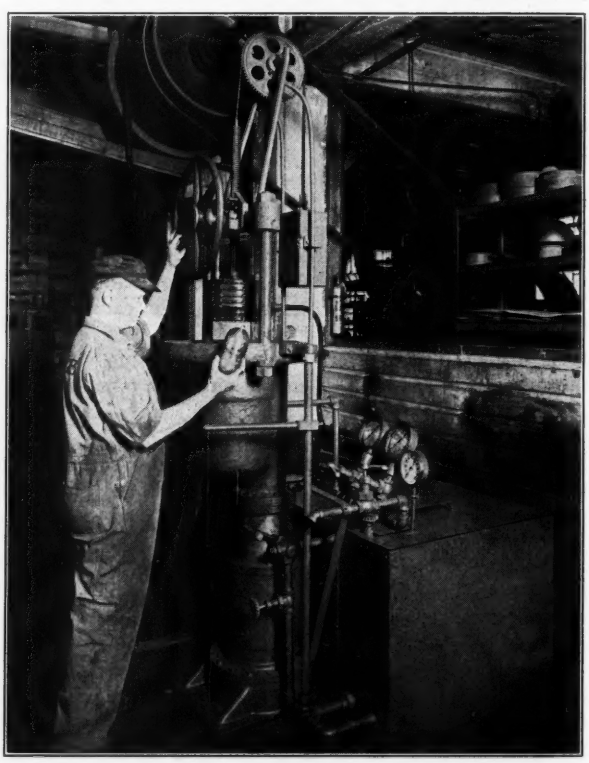


FIG. 3. FLOATS ARE TESTED TO TWICE WORKING PRESSURE

Characteristics of the liquid must be considered as its specific gravity determines the weight of the displaced volume. Temperature may affect the material of which the float is made and the material must resist corrosive action. Two other factors, size and shape, enter into the problem and it should be remembered that, for a float under pressure, the ideal shape is the sphere.

*Reliance Gauge Column Co., Cleveland, Ohio.

Seemingly, the practice in designing a device containing a float is to pick a float of a size to fit the available space but the correct procedure would be to design a float of the right size to perform the work, then make the space of size to fit the float.

In designing a float, the following items must be considered: (a) Pressure under which it works and any mechanical strains; (b) characteristics of liquid such as specific gravity (weight in ounces per cubic inch) and corrosive action; (c) temperature; (d) size and shape limitations; (e) displacement, weight, buoyancy; (f) connecting mechanism.

Strength Needed

As floats under pressure are in compression and are usually of spherical or other difficult shapes it is impractical to calculate their strength from any but empirical formulas. The careful designer determines the collapsing pressure of known floats by actual test, then plots curves for other sizes and pressures and checks a sufficient number to prove the curves. Strength of the float must be sufficient to withstand not only a constant pressure but also rapidly fluctuating pressures and in some cases water hammer or pounding against the walls of the containing chamber, although well-designed apparatus provides means to prevent the float striking anything with much force. Strength of the material has as much bearing on the strength of the float as the thickness or shape, hence in recent years, copper has given way to nickel and monel metal which have over twice the strength for the same weight.

Buoyancy Required

Specific gravity of the liquid is of vital importance and must be known, especially at the operating temperature. Many cases of float trouble have been due to failure to consider the change in weight of water with temperature. The following table shows how the weight in ounces of a cubic inch of water varies at different temperatures corresponding to certain steam pressures:

WEIGHT OF WATER IN OZ. PER CU. IN. AT VARIOUS TEMPERATURES

Steam Pressure, lb. per sq. in.	Temperature, Deg. F.	Wt. Water, oz. per cu. in.
	68	0.576
0	212	0.554
25	267	0.539
50	298	0.531
100	338	0.518
150	366	0.509
200	388	0.499
250	406	0.492
300	422	0.486
400	448	0.475
600	488	0.456
1200	569	0.409
1500	597	0.389

Importance of this factor may be illustrated by the following: A 3-in. diam. spherical float weighing 6 oz. has a volume of 14.14 cu. in., and a buoyancy of 1.3 oz. in water at the pressure of 100 lb. (steam temperature 338 deg.); but only 0.4 oz. buoyancy at 600 lb. pressure (489 deg.); and no buoyancy at all at 1050 lb. pressure (550 deg.).

In the oil industry, a knowledge of the specific gravity of the liquid at the operating temperature is even more important. It is also important to know just what action the liquid will have on materials available for floats. It is well known that aluminum must not be used in boiler waters and copper must not be used in crude oil. Of course, iron and steel are of short life in any water. Chromium is becoming a factor in floats for the oil industry.

Temperature, Pressure and Strength

Temperature effect of the liquid may be a determining factor. The soldered float must not be used above 400 deg. F., even with high-temperature solders. Copper, the most common of all float materials, begins to lose its rigidity around 450 deg. F. and becomes quite soft at 500 deg. F. but nickel and monel metal hold up under temperatures as high as 800 deg. F., which is much above any saturated steam temperature.

For floats under pressure, it is desirable to use the spherical shape, if possible, or next best the float shown being tested in Fig. 3, which has spherical ends and a reënforced cylindrical center. Size and shape of the container are sometimes limited so that the ingenuity of the designer is taxed to deliver a form to meet these limitations.

Size to Give Buoyancy

Weight of the liquid which is displaced when a float is completely submerged is called the displacement. This varies with the size of the float, also with the specific gravity of the liquid, and will vary in a given liquid as the temperature changes. For a spherical float the volume in cubic inches is equal to $0.5236d^3$, where d is the diam. in inches. The displacement $= 0.5236d^3$ w, where w = specific weight of the liquid. It is customary to figure the displacement, weight and buoyancy of floats in ounces, hence w is weight in ounces of one cubic inch of the liquid.

Buoyancy is equal to the displacement minus the weight of the float. If W is the weight of the float in ounces then

$$\text{Buoyancy} = 0.5236d^3\ w - W$$

Float Connections

In some devices, the float is permitted to move freely in the container but in most cases it is attached to some mechanism and the attachment must be carefully designed. Mechanically, the best connection is by a rod passed through the float but the difficulty of maintaining a perfectly tight joint at the points where the rod passes through the shell bars this method. A good method, not much used at the present time is to pass flexible bands around the outside of the float, thus distributing the load over the float but this construction has a tendency to work loose, also is heavy and expensive. The most common form of attachment is by means of a spud, A Fig. 3, attached to the outside of the float and with a pipe or taper thread which will not shake loose. Another common form of spud is shown in B Fig. 3.

Sometimes devices do not function properly because of the float but it is because the float used is wrong or was not correctly designed or made. Today there is no reason why such a condition should exist. Design and manufacture have reached a point where any reasonable requirement can be met and the utmost in service and reliability delivered.

Operating Procedure in the Boiler Room

DIVISION OF RESPONSIBILITY AND PROCEDURE BY THE ONCOMING SHIFT ENGINEER OUTLINED BY N.E.L.A.

DEFINITE PROCEDURE and a systematically arranged schedule are well established principles of plant economy and reliability. The incoming engineer should make a thorough inspection of all equipment before taking over his shift and, if the plant is too large for him to oversee every detail, the duties should be definitely assigned to a responsible member of the crew.

The following rules were made to serve as a guide in formulating rules and procedure for any given plant: In order to avoid duplication, the rules have been made so as to apply both to stoker fired and to pulverized fuel fired boilers. To assist in fixing the application of a rule to the specific type of installation, the following nomenclature has been adopted: Rules which apply to both stoker and pulverized fuel installations have no marking other than the number of the rule itself, such as Rule 2; rules which apply solely to stoker fired boilers have the letter S following the rule number, such as Rule 6-S; rules which apply solely to pulverized fuel fired boilers have the letter P following the rule number, such as 3-P.

Rules for stoker fired boilers have been drawn up particularly for underfeed stoker installations, but it should be readily apparent where these rules should be modified in particular cases to cover other types of stoker firing. Blank spaces indicated as (. . . .) are to be filled in by plant engineers to suit their individual plant operation.

INSPECTION BEFORE TAKING OVER THE SHIFT

At the beginning of each shift, before taking over the shift, the water tender or boiler operator must proceed as follows:

1. Blow down the water column and gage glass on each boiler and test the gages by opening the gage cocks to determine the water level. This should be done by the water tender or boiler operator, but anyone else detailed may blow down duplicate columns under supervision of the water tender or boiler operator.

2. Observe fires, ratings and instruments; then judge if fuel feed is correct for maintaining the load or for correcting furnace conditions or ratings. Attached to each boiler should be a chart of instructions developed for proper operations under normal conditions. If it is impossible to adhere to these instructions, the boiler engineer should be informed.

3. Examine the gage board to see that all instruments are in operation.

4. The water tender or boiler operator leaving the shift must report to his relief any unusual or special conditions pertaining to the apparatus and fires. Special attention must be given in this report to the condition of the automatic feedwater regulators and hand operated feedwater valves.

5. On taking over the shift, the water tender or boiler operator assumes full responsibility for further operation.

1. After assuming responsibility for the shift, the boiler operator or water tender must not leave the boiler floor under any consideration without notifying the shift superintendent or boiler engineer. In any event, the water tender or boiler operator is at all times responsible for boilers assigned, and must not leave the floor in time of trouble or impending trouble.

2. Maintain about ..... to ..... gages of water in each boiler when steaming.

3. All boilers should be operated at or near the same rating, except when specific characteristics of individual boilers demand a departure from this rule.

4. Draft and fuel feed should be set, using instructions posted by supervisory force, on bulletin board as a guide, altering them, if necessary, to suit existing conditions.

5. Always maintain the draft over the fire as stated on the chart. Exception is made to this only for a short time before dumps in stoker fired stations having no means of putting air on the extension grates and in emergency cases.

6-S. All extension grate dampers should be opened according to the general instructions of the boiler engineer.

7. To determine their condition, fires should be inspected by the water tender or boiler operator from the front, side and rear doors from time to time and when instrument indicates irregularities. This should be done by the aid of colored glasses made for this purpose.

8-S. When dumping time approaches all fires must be inspected and those fires which have unburned coal on the dump plates should, if possible, be burned down in the rear before dumping. If there is so much coke on the dump plates that it is impossible to burn it down properly, this coke should, if possible, be winged back on the fire with a bar.

9-S. Dump each fire as rapidly as possible but allow sufficient time between boilers so that the steam pressure will not be affected.

10-S. With boilers equipped with clinker crushers care must be taken to see that large clinkers do not form in such a position that they will not go through the rolls. This type of clinker should be hooked around with a bar so that its length is parallel with the clinker crusher. The ash should be held in such amount as permits of best furnace operation.

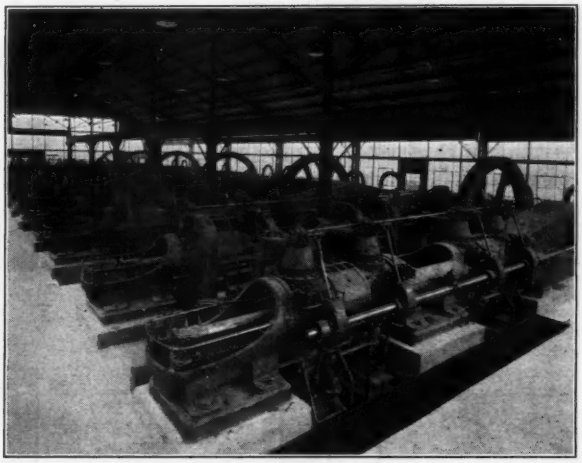
11. Blow down the boiler from both the main and surface blowoff (when provided) according to the instructions of the boiler engineer. The main blowdown should be made with the boiler banked, if possible, or steaming capacity checked.

12. The blowoff valves of the economizers should be operated according to instructions of the boiler engineer.

13. The procedure in blowing down main blowoffs is as follows: 1, open plug cocks with lever wrench; 2, open main blowoff valves slowly; 3, close main blowoff valves slowly; 4, close plug cocks with lever wrench. While blowing down, the water tender should watch the level of the water in the gage glass.

14. The following items should be entered on the boiler room log sheet by the designated person: a, the number of hours each boiler was steaming, banked and out; b, the time of dumping; c, the number of hours the fans were in operation; d, the reading of the stoker counters at midnight; e, the amount of blowdown.

Two New Gas Compressor Stations Serve Kansas Gas Lines



Abilene Station of Kansas Pipe Line & Gas Co. has a capacity of 41,160,000 Cu. ft. a day, with six 1,000-hp. units installed. Calista Station Contains three similar 1,000-hp. units.

TWO GAS COMPRESSOR stations, recently completed at Abilene and Calista, Kan., are the first of five stations which will eventually be required on the Kansas Pipe Line & Gas Co.'s 18-in. and 16-in. main line extending from Mullinville, Kan., and near Medicine Lodge, Kan., through Calista, Hutchinson, McPherson, Abilene and Clinton, to the Nebraska-Kansas state line near Chester.

In addition to providing an outlet for gas from the fields in Barber, Harvey, McPherson and Marion Counties, this trunk line is interconnected at Mullinville and Clifton with the Missouri Valley Pipe Line Co.'s 24-in. line, which extends from the Texas Panhandle to Mullinville, Kan., and from Clifton, Kan., to points in Eastern Nebraska and Northern and Western Iowa. Near Chester, Neb., the Kansas Pipe Line & Gas Co. line connects with the 16-in. line of the Nebraska Natural Gas Co., which extends from this point to Grand Island, Neb., with branch lines east and west.

At the present time and probably for the next year or two, the Kansas Pipe Line & Gas Co.'s 16-in. line will carry from Mullinville to Clifton all of the gas used by the Missouri Valley Pipe Line Co. in Nebraska and Iowa, thus deferring construction of approximately 185 mi. of 24-in. line between the two points. With this arrangement in mind, the construction of these compressor stations was commenced late in 1930 and completed early in 1931.

Abilene station, which is the larger of the two, is located on a tract of 40 acres, two miles south of Abilene and adjacent to the 16-in. line. The general arrangement of the station is shown in Figs. 1 and 2.

Abilene Station

The main building, housing the six 1000-hp. gas-engine-driven compressors, is 69 ft. wide and 179 ft. long, of steel and corrugated iron construction. This building was furnished by the Pittsburgh-Des Moines Steel Co. of Des Moines, Iowa. It is equipped with two Chisholm-Moore 10-t. I-beam geared hand-power travel-

FIG. 1. GENERAL VIEW OF ABILENE COMPRESSOR STATION, SHOWING COOLING TOWER AND WATER STORAGE TANK

ing cranes, each equipped with a 10-t. geared overhead carriage and a 10-t. two-speed Cyclone hoist.

Compressor and engine units, as shown, consist of Cooper-Bessemer 21½-in. by 36-in. twin tandem, double-acting 1000-hp. gas engines, each direct-connected to two 13½-in. by 36-in. double-acting compressor cylinders operating at 250 lb. suction and 430 lb. discharge pressures. Each unit operating at 125 r.p.m. has a capacity of 6,860,000 cu. ft. of gas per 24 hr., giving the station a capacity of 41,160,000 cu. ft. per day. Forced feed lubricating system is provided for the engines and compressors. Ignition current is furnished by batteries located in the basement of the main compressor room.

Cooling water with an inlet temperature of 89 deg. F. circulates through the jackets of the compressor and engine cylinders. This water leaves the jackets at a temperature of 132 deg. F. and flows to a hot well, from which it is pumped to an atmospheric cooling tower, which reduces the temperature to about 79 deg. F.; then flows it through the gas coolers, where the temperature is raised to 89 deg., at which temperature it again enters the jackets of the compressors and engines. The quantity of water handled is approximately 1200 g.p.m. and to pump this water there are provided three Cameron centrifugal pumps, each direct-connected to a 25-hp., 1750-r.p.m., 220-v. motor.

The cooling tower is a Fluor, as shown in Fig. 1, containing gas coolers capable of handling 75,000,000 cu. ft. of gas per 24 hr. The coolers are designed for 400 lb. normal working pressure and, with the water temperatures mentioned previously, will cool the gas from a temperature of 234 deg. F. to 92 deg. F.

Compressors for supplying the air to start the engines on the main compressor are housed in the auxiliary building. There are two units, each consisting of a 5½ by 2¾ by 5-in., type 20, 2-stage vertical single-acting compressor direct-connected to a 15-hp. motor, which is arranged for automatic start and stop control, cutting in at 175 lb. and out at 200 lb. Air is compressed into a tank shown at the end of the auxiliary building. This auxiliary building also contains the office and lockers for the attendants.

Calista Station

Calista station, which is located at the junction of the 18-in. line from Mullinville and the 16-in. line from Barber County, contains three 1000-hp. units and is similar in design to the Abilene station.

Compressing units consist of 21½ by 36-in. twin tandem, double-acting 1000-hp. Cooper-Bessemer gas engines direct-connected to 11 by 36-in. double-acting compressor cylinders, operating at 255 lb. suction and 575 lb. discharge pressures, each unit having a capacity of 6,800,000 cu. ft. of gas per 24 hr.

In this station electrical energy is furnished by two units, each consisting of a 11½ by 14-in., 3-cylinder, 4-cycle Cooper-Bessemer vertical gas engine direct-connected to a 75-kw. generator.

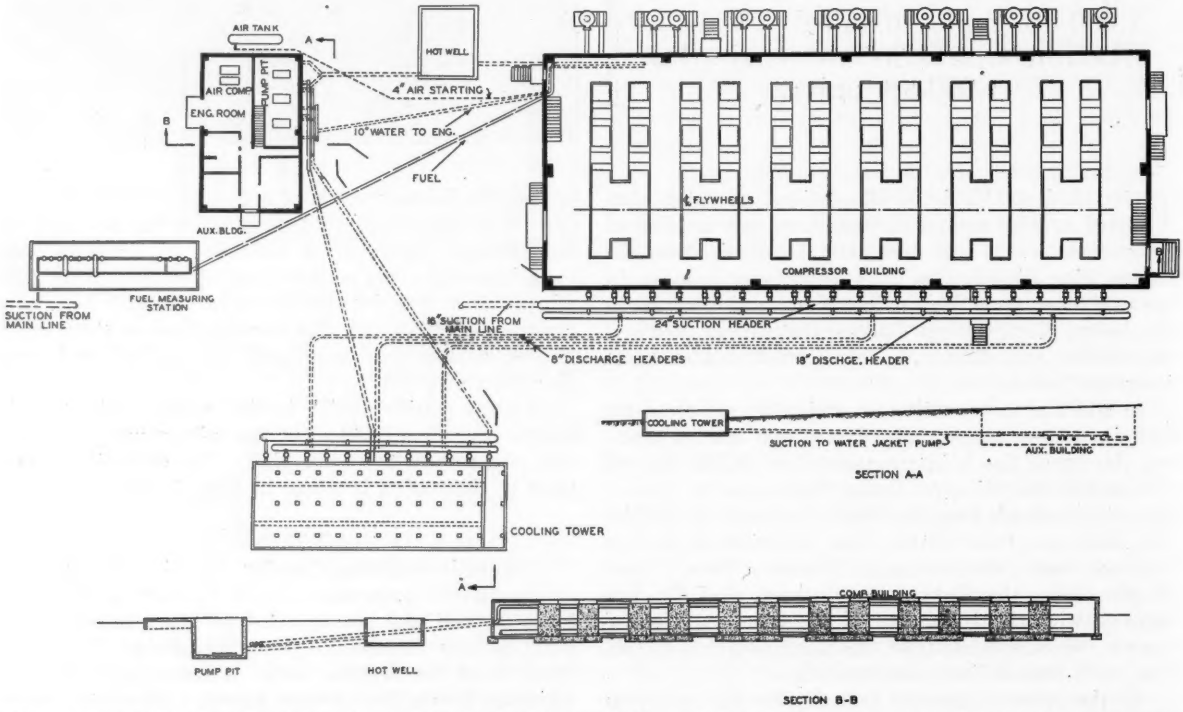


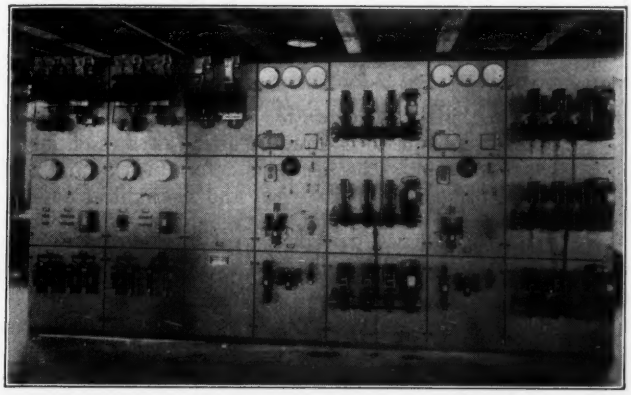
FIG. 2. GENERAL ARRANGEMENT OF ABILENE STATION SHOWING WATER PIPING AND DETAILS OF CONSTRUCTION

February sales of mechanical stokers as reported to the Bureau of the Census by the 11 leading manufacturers total 67 stokers of 40,249 hp. as compared to 85 of 25,902 hp. in January and 73 of 22,648 hp. in February, 1930, and 80 of 31,554 hp. in February, 1929. Of the 67 stokers sold in February, 1931, 37 were installed under fire-tube boilers of 5326-hp. capacity and 30 stokers under water-tube boilers of 8923-hp. capacity.

Control of Electrical Equipment *in* Industrial Plants

Part I

by E. H. Stivender



NOT ONLY HAS the general adoption of remote control greatly improved safety but it has brought about increased efficiency, reliability and economy of operation. It has permitted the operator to be stationed at the most suitable position and has decreased labor costs greatly in many cases. Control rooms and control stations can be made much smaller and power switching equipment can be located at any point desired, practically disregarding the physical location of the control station.

When using the word remote control, electrical operation of circuit breakers from some removed point is usually meant, however, there are many installations for the control of circuit breakers known as remote control where the breakers are operated mechanically from the switchboard through an arrangement of levers and bars. The operating bars are often under the floor and hence inconspicuous. This practice is mostly limited to the control of circuit breakers not over 25 ft. from the switchboard.

Air pressure from storage tanks has been tried in an effort to eliminate electrical control, but due to mechanical complications has not been entirely satisfactory.

Electrical operation consists of either an alternating or direct-current control source, which is used to operate circuit breakers by means of motors or solenoids. The limiting distance away at which circuit breakers may be operated is determined by the line drop of control cables, hence the control voltage range at which the circuit breakers will satisfactorily operate.

Owing to problems of self-inductance, the economy of alternating-current control is somewhat poorer than direct current when used for large installations, also where reliability is a presiding factor, direct current has the advantage of permitting the use of storage batteries, thereby making the control source independent of the power source.

To be efficient, a solenoid must necessarily have high self-inductance, since good operation depends upon a low reluctance magnetic circuit and a high value of ampere turns. For this reason, many circuit breakers whose energy for closing depends upon an alternating-current source, operate very unsatisfactorily when this energy is furnished by means of solenoids. Alternating-current control of oil circuit breakers usually employs some form of motor operated closing mechanism. The motors used are series wound and some means is provided whereby the motor has opportunity to accelerate before the load is applied. Development of motor operated circuit breaker mechanisms has resulted in a number of different types being produced by various manufacturers.

Economy of alternating-current control in many small and medium sized installations has been proved conclusively in the last few years. The scope of this form of control is being continually expanded with the development of reliable operating mechanisms and switchboard apparatus. At the same time, great developments are being made in equipment operated by direct current. Motor operated mechanisms for use on direct-current control systems have been devised which are often preferable to solenoid operated mechanisms. For some types of circuit breakers, motor operated mechanisms have been found to be faster in operation and to require less current for closing than similar types employing solenoids.

There are also the motor operated breakers which use the energy stored in springs for closing and tripping.

Remotely controlled starting compensators for the smaller a.c. motors nearly always employ alternating-current solenoids for closing. The energy required for operating the mechanisms is not so large as to prohibit the use of solenoids, thus allowing for a more economical as well as simplified unit. The closing solenoids are often continuously energized while the circuit breaker is in operation; this gives low-voltage protection and eliminates the use of trip coils. Objectionable hum is reduced by the use of shading coils in the cores of the closing apparatus.

Often a combination of alternating and direct-current control is employed. This practice includes the cases of separately excited synchronous motors. Exciters driven by a.c. motors furnish direct current for the closing of circuit breakers as well as excitation for the motor

fields. Protection against failure of the alternating-current supply is furnished by undervoltage coils whose plungers act directly on the trip mechanism when the voltage falls too low for operation.

This practice combines some of the advantages of both direct and alternating-current control systems. It possesses the economy of the alternating-current system by eliminating the expense of a storage battery and charger, and it has the simplicity and speed of operation which are inherent in d.c. control systems.

Another combination of d.c. and a.c. control systems

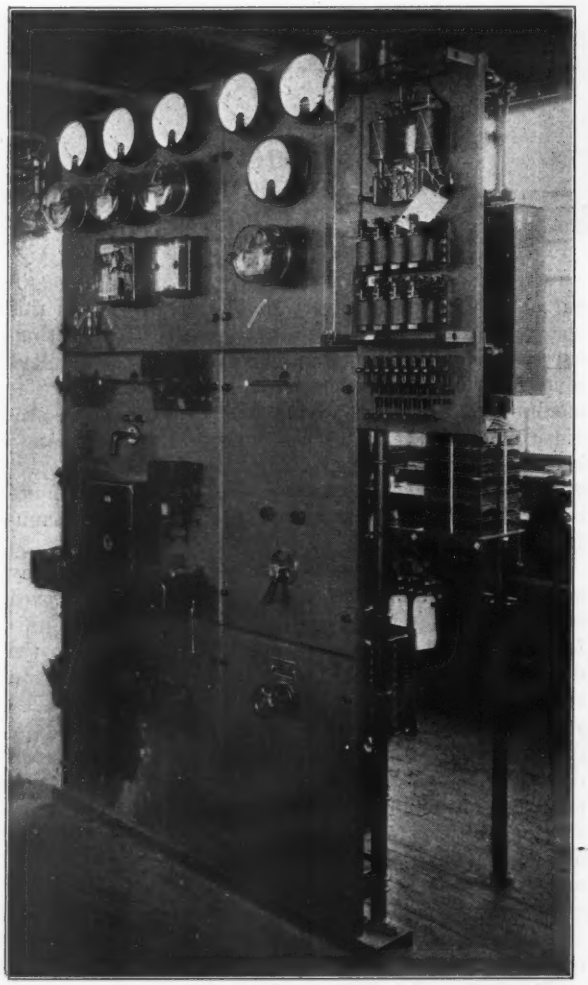


FIG. 1. AUTOMATIC CONTROL FOR SYNCHRONOUS MOTOR AND SINGLE PHASE A. C. GENERATOR

is where the closing current is alternating, while tripping current is furnished by a small battery equipped with a charger. This system combines the advantages of an independent trip circuit with the reduced investment and maintenance offered by alternating-current control. It is particularly adapted to small installations operated by supervisory control, the storage battery being used for operating control relays as well as trip coils.

In instances where the energy for closing small air-break circuit breakers must come from an alternating-current supply, one manufacturer uses a small copper-oxide rectifier in the solenoid circuit. These rectifiers require practically no maintenance, hence this system is equipped to form a highly reliable and efficient control scheme for small installations which do not justify the expense of storage batteries with their attendant maintenance and operating costs.

The type of control used as determined by the desired method of operation, the class of power apparatus being operated, the extent of reliability desired, and the allowable investment and maintenance costs.

Protective Relays

Reliability of operation and adequate protection against damage to equipment are always essential in a control system. The former is determined by the design and construction of electrical and mechanical details of the control circuits and the reliability of the control power source, the latter by the class of power equipment being operated and the proper selection and design of protective relays and trip circuits.

Protective relays and relay systems commonly used with motor control circuits are (1) over-current relays, consisting of temperature relays, inverse time limit plunger type relays, inverse time limit induction type relays, and instantaneous relays; (2) under-voltage and over-voltage relays, including both instantaneous and time limit types; (3) differential relays, (4) open and reverse phase relays.

The use of any particular type or types of protective relays depends upon the importance of continuous operation and the kind of equipment protected. Since the mechanical construction of most modern motors enables them to stand severe sudden overloads, it is often undesirable that a motor be disconnected from the line when periodic overloads occur. Aside from heavy magnetic stresses encountered, the load limit of any electrical apparatus is determined by the safe temperature at which the insulation of the machine can remain in service. For this reason, the use of temperature relays for the protection of motors in all classes of service has become quite general. These relays are made in different types; some consist of thermometers which close contacts completing the trip coil circuit at a pre-determined temperature; other types use resistance thermometers in connection with overload relay elements. Another principle of operation is that of relays containing bimetal strips which are heated by a current equal or proportionate to the current in the motor windings. This type of relay does not employ any direct means of determining the temperature within the motor but is placed in the same room or a room whose temperature changes in accordance with that in which the motor is located, hence, the relay can be set to close its contacts when the temperature of the motor windings reaches a pre-determined value above ambient temperature. The relay heater coil is so constructed that its temperature coefficient approximates that of the motor windings, therefore the bimetal strip being heated and which carries the contacts experiences practically the same temperature changes as the insulation of the motor. The contacts will not close until the temperature of the bimetal strip and hence that of the insulation of the motor reaches a certain value, brief overloads will not operate the relay. With this scheme of protection, the motor will not be disconnected from the line until actual danger to the insulation is anticipated.

Since temperature relays will not act in sufficiently

short time to insure protection against short circuits in the motor windings and leads, additional overload relays are often provided for immediately opening the circuit breaker when such faults occur. These relays are used in addition to temperature relays and often exclusively to any other relays. When used with temperature relays they should have an operating current setting of a slightly higher value than that of the temperature relays. They may be either instananeous, definite time or inverse time. Overload relays designed operate instantaneously when the current rises to a certain value are infrequently used, they cannot satisfactorily be set for a particular time characteristic, as is usually desired.

Relays employing a time element of oil dashpots are frequently used with starting compensators and with some oil switches. They offer adequate protection in most cases but where a constant time characteristic independent of temperature is essential, there generally is an error, since temperature affects the body of oil. When overcurrent takes place, the plunger either trips the breaker mechanically, opens the circuit of continuously energized solenoids, or energizes a trip coil circuit, depending upon the type of circuit breaker mechanism used.

FIG. 2. FRONT VIEW OF MAIN METERING AND CONTROL SWITCHBOARD USED TO CONTROL METAL CLAD SWITCHGEAR IN STEEL MILL SERVICE

A prominent air-dashpot relay consists of a small plunger and solenoid acting through a spring on a bellows; the time limit is adjusted by means of a valve on the bellows; the setting of this valve determines the amount of air which can escape at a given pressure. Since the magnetic force acting on the plunger determines the air pressure in the bellows and the volume of air escaping from the bellows is proportional to this pressure, this relay has inverse time characteristics; the greater the current through the solenoid the shorter will be the operating time. It is desirable that a relay have instantaneous characteristics when the current reaches a certain valve, such as when a short circuit occurs in the protected equipment; in this particular type this feature is obtained by means of a spring which couples the plunger with the bellows. If the current suddenly rises to a given abnormal value the spring is compressed, allowing the contacts to close independently of the setting of the bellows, thereby giving a nearly instantaneous effect. Various current settings are provided by changing the position of the plunger relative to the coil.

Induction time element relays operate on the principle of the induction motor and closely resemble watthour meters. Torque on a non-magnetic disc produced by a rotating magnetic field which is excited by the line current, causes the disc to rotate and close the trip circuit. The time element is supplied by a magnetic field of permanent magnets which, by induction of eddy currents in the disc, cause attraction and repulsion between the magnets and disc when it rotates, thereby producing retardation.

The time setting is made by determining the distance the disc must travel before the contacts will close. The current required to operate the relay is determined by means of taps on the actuating coil. The disc moves against a spring which, in addition to offering a counter torque to the current coil, moves it back to normal position when the current recedes. Instantaneous operation above certain current values is produced by means of an iron core reactance coil, when the core becomes saturated the reduction of reactance permits larger values of current to flow in the actuating coils, hence torque on the disc increases in much greater proportion than when the current through the reactor was below the saturation point.

All relays of this type manufactured by one company operate their contacts through a train of gears, the contacts are held closed by a magnet whose coil is in series with the trip circuit, thus preventing excessive arcing and burning. Another company manufactures its standard relays with no gear train, while longer time elements are accomplished by means of gears, a small auxiliary relay whose coil is in series with the trip circuit and which is held closed by its own contacts until the circuit breaker opens serves to relieve the main contacts of interrupting any current.

Relays used to open breakers in care of open or reserved phases will be discussed in a subsequent article.

HALFORD ERICKSON, vice-president in charge of operation, Byllesby Engineering and Management Corp., announces that Standard Gas and Electric Co.'s construction budget for 1931, totaling $45,068,951, has been allocated among various subsidiary and affiliated companies as follows:

The California Oregon Power Co.	$ 5,100,004
Louisville Gas and Electric Co.	3,100,066
Mountain States Power Co.	1,115,530
Northern States Power Co.	10,803,809
Oklahoma Gas and Electric Co.	3,577,502
San Diego Consolidated Gas and Electric Co.	2,271,060
Southern Colorado Power Co.	240,357
Wisconsin Public Service Corp.	1,508,245
Wisconsin Valley Electric Co.	1,027,474
Philadelphia Co.	14,028,096
Other construction expenditures, allocation of which has not been completed.	2,296,808
	$45,068,951

Construction included in the amounts indicated provides for an additional generating unit of 35,000-kw. capacity now being built at the Riverside plant of Northern States Power Co. in Minneapolis, further hydroelectric development for The California Oregon Power Co. and two transmission lines now under construction.

Electricity---What It Is and How It Acts*

PART L. THE ELECTRON AND THE PROTON AS FACTORS IN EXPLAINING RADIATION FROM THE SUN AND STARS. BY A. W. KRAMER

SO FINALLY we come to the question, what are the electrons and protons themselves? We have described their action in detail, we have calculated their weight and electric charge and have watched them perform with extraordinary vividness. In the neutral atom we have seen them together, living in apparent connubial bliss; in the excited or ionized atom, we have seen this happy partnership violently dissolved, smashed, the home broken, disorganized by the departure of one member of the household for parts unknown. We have seen these ejected electron return home so to speak, sometimes boldly, without knocking, at other times hesitatingly as though penitent, stopping at each energy level but always, whether boldly or timidly, subject to the iron rule of the quantum. Entering the confines of the atoms with speeds a thousand times that of our fastest express trains, we have seen these wandering electrons caught—tripped by one or another energy level to become whirling satelites while their energy was liberated to fly across the limitless expanse of the universe. For such is the nature of the transmission of light, that the quanta radiated by a single atom can travel a hundred million years across the breadth of the universe and never undergo the slightest diminution either as to amount or quality.

Yet, despite the vividness of the descriptions of these processes, of the electron itself and its positive counterpart, the proton, we know very little. No familiar conceptions—no analogies—can be employed to give us a better understanding of the electron itself; it, as Eddington puts it, belongs to the waiting list. It remains to be explained. And as has been pointed out before in these chapters, even these processes which involve the activities of the electron and radiation phenomena must be taken with the proverbial grain of salt. The rejection of an electron by an atom or the acquisition of one, or the transition of an electron from one orbit to another is merely a way we have of picturing in our minds a change of state of the atom which cannot really be associated with movements in space as we know it. Activities within a space a hundredth millionth of an inch can have no significance for us. We only know something is happening but what this something is, or what is happening we do not know. In the words of Eddington again, *something unknown is doing we don't know what.*

THE SIGNIFICANCE OF NUMBERS IN ATOMIC CONCEPTIONS

From this it might seem that our entire discussion of these matters has been futile, for apparently after some fifty chapters of detailed description, we now imply that we don't know what we have been talking about. But it is not quite as futile or hopeless at it may appear. For, if it is true that these processes we have described are largely matters of our imagination, it is true also that by these processes we describe and correlate a large number of different and apparently unrelated phenomena. Also, by means of them we make predictions and these predictions quite often come true. So, we cannot be entirely wrong.

The truth of the matter is, that numbers are con nected with our descriptions and these numbers impart to them a realism that is sometimes startling. The mere conception of electrons circulating in an atom is but imparting the picture we have of our solar system to the atom. It may be true or it may not be true—we have little direct evidence that it is so. But when we picture seven electrons circulating in one atom and eight in another and thereby are enabled to understand the difference between nitrogen and oxygen, we can feel fairly certain that we have hit upon something fundamental.

So it seems that numbers are of greater importance than mere mental pictures and this is becoming more generally recognized as we delve more deeply into the nature of physical phenomena. But mathematics is an abstract science and those of us who are not mathematically minded find that it is difficult to think in terms of symbols as does the mathematician, so we resort to analogies and comparisons and mental pictures, all of which at best are makeshifts. For it is probable that the fundamental mechanism of the universe is so constituted that we cannot think of it in any of the terms that enter our experience and that it can be expressed only in terms of mathematics.

But to return to our electron and proton—somehow we always seem to stray, although there is probably a good reason for this which the reader may have guessed —we do so because we are trying to explain something we know fundamentally cannot be explained.

It has been shown that because of their opposite nature, electrons and protons apart represent potential energy—the farther they are apart the greater the potential energy. What, then, would happen if an electron and proton should succeed in coming completely together?

In this question probably lies the ultimate mystery of nature and the answer to it will go a long way toward explaining the universe. And, strange to say, the answer probably is just what we might expect it to be. When a proton and an electron come together, they completely annihilate each other, setting their energy loose in space as radiation. By means of the Einstein theory of relativity, it is possible to calculate the amount of energy that what be produced by the annihilation of a given amount of matter. It can be shown that the energy is set free at the rate of 9×10^{20} ergs per gram, regardless of the nature or the condition of the substance which is annihilated.

This is extremely interesting, for it represents an amount of energy release which enormously transcends anything in our experience. Compared to it, the energy released from the combustion of coal is as nothing. The combustion of a ton of the best coal in pure oxygen for instance liberates about 5×10^{16} ergs. If, however, this same ton of coal were completely annihilated by the neutralization of the electric charges in all the atoms

constituting that ton of coal, the energy liberated would be 9×10^{26} ergs, about 18,000 million times as much.

As stated by Jeans,[1] in ordinary combustion we are merely skimming off the top-most cream of the energy contained in the coal with the consequence that 99.999999994 per cent of the total weight remains behind in the form of smoke, cinders and ash. Annihilation leaves nothing behind; it is a combustion so complete that neither smoke, ash nor cinders is left. If we on earth could burn our coal as completely as this, a single pound of coal would keep the whole entire British nation going for two weeks. Our present steam electric generating plants, it seems, are only about .0000000012 per cent efficient!

This is all very well for exercising our imaginations; but, it may be asked, why concern ourselves with matters which obviously are impossible? Of what use is it to concern ourselves with such fanciful ideas; is there any evidence that they can ever occur? If matter can disappear in this way, under what circumstances is it brought about and why has this startling fact never been shown by many careful and ingenious experiments on gravitation carried out during the last hundred years?

The Source of the Sun's Heat

This is precisely why this discussion was introduced, for there is evidence that it does occur and it is upon this basis that modern astronomers explain the radiation of energy from the sun and stars. The reason the fact has never been shown in experiments made on earth, is due to the extremely large coefficient in the relation between matter and energy, 9×10^{20}. Experiment is almost hopeless before the twentieth power of ten.[2]

But in the sun and stars the amounts of energy involved are so enormous that it is only by some sort of an energy release rate as this, that their continued radiation throughout the ages can be accounted for. As Jean's points out in his fascinating book, "The Universe Around Us," many attempts have been made to account for the sun's heat but with the exception of the one just referred to, i.e., that due to the complete annihilation of matter by complete neutralization of the electric charges, none have proved tenable. Various theories had been advanced—some involving the contraction of the sun's mass, others, the disintegration of radio-active substances, that is, the breaking up of complex atoms into simpler ones, but none of them when put to the test of rigid mathematical calculation survive. None of them is able to account for sufficient radiation of energy throughout the stupendous length of time which modern astronomy shows the sun has existed. Even the last one mentioned (radio activity) which involves the most energetic energy liberation known on earth fails to account for the sun's energy.

So we have no alternative but to conclude that the radiation from the sun is being maintained by the rushing together of positive and negative electric charges, annihilating one another and setting their energy free as electromagnetic radiation. Knowing the value of the sun's radiation, it is possible to calculate the amount of mass that must be annihilated each second.

The total energy radiated by the sun each second, indeed, is enormous. Converted into its mass equivalent, it gives us the startling figure of 4 million tons per second! Offhand this might appear entirely too great, but even in the astronomer's laboratory we find that this enormous loss of mass is difficult to detect. For so super-enormous is the sun's mass that, even at this terrific rate of mass expenditure, it is good for something like ten million million years!

Thus it seems that our sun and all the other stars are slowly dissolving into light.

Conditions Necessary for Annihilation of Matter

Now, under what conditions do the electron and protons annihilate each other in this manner? Certainly it is possible only under the most extraordinary conditions, for, as stated above, we know of nothing in our own experience that permits or induces it. It must involve a degree of excitation far beyond our knowledge. Indeed, the quantum theory indicates a degree of stability within the atom which accounts for the stability of the universe itself.

Electrons have been shown to be capable of occupying certain orbits or energy levels within the atom. Thus the electron in the hydrogen atom normally occupies what is known as the K ring. The helium atom has two electrons in this K ring, but this is the maximum number of electrons this particular ring can accommodate for in the next atom, the lithium atom, which has a total of three electrons, the third one occupies an orbit by itself, the L orbit.

Now, it is possible for the single electron of the hydrogen to occupy an orbit other than the K orbit but this occurs only when the atom is excited in one way or another. Ultimately, however, this electron will revert to its K orbit. And this holds true for all atoms. Provided the electrons are not being excited by radiation or other stimulus, each atom sinks in time into a state in which the electrons are occupying orbits of lowest energy.

As far as our experience goes, we find that no electron can get closer to the nucleus than the orbit of lowest energy. As stated by Jeans',[1] as soon as an atom reaches this state it becomes a true perpetual motion machine, the electrons continuing to move in orbits without any of their motion being dissipated away either in the form of radiation or otherwise. It seems astonishing and incomprehensible that an atom should not be able to yield up its energy still further but so far as our experience goes it can not; and this property, though little we understand it, is responsible for keeping the universe in existence.

If no such restriction existed, the whole material universe would disappear in the form of radiation in a few thousand millionths of a second. The quantum law states that an atom radiates energy only when electrons jump from one orbit to another and then only in certain definite (no more, no less) amounts known as quanta.

Before the quantum theory was evolved, the only basis available for explaining the radiations from an

[1] The Universe Around Us.

[2] In discussing this question, Paul Heyl of the Bureau of Standards in an article in the scientific monthly, October, 1925, shows clearly the difficulties involved in attempting to test the process experimentally. The theory asserts that when a hot body cools off, emitting light and heat, it must lose a little of its mass by radiation. For example, a gram of water at 100 deg. will have when cooled to zero a mass less than one gram by the mass-equivalent of the energy that has been radiated away. To calculate this we divide the 100 calories, or rather 4.2×10^9 ergs, by 9×10^{20}, obtaining about 5×10^{-12} gram. Now even when dealing with masses of the order of a kilogram, it is not possible at present to detect a difference less than one part in a million, 10^9.

atom, were the 19th century classical laws of physics. In accordance with these laws, the radiation of energy was a direct consequence of the rotation of the electrons in their orbits, and energy was radiated continuously at the expense of the rotational energy of the atom. That this basis was not the correct one was readily apparent, for if radiation took place in this manner, the atom would (as a consequence of this continuous loss of energy) begin to shrink at the rate of over a meter per second. Thus after a thousand millionth part of a second, the nucleus and the electron would meet and the whole atom would disappear in a flash of radiation. By prohibiting any emission of energy at all where their are no quanta available for dissipation, the quantum theory succeeds in keeping the universe in existence as a going concern.

In this view of atomic stability, it must be understood that we are considering what we are pleased to call normal conditions—not such highly excited states as may exist in the interior of the sun and stars. It is probable that at temperatures of from 20,000,000 to 40,000,000 degrees, such as prevail in the interiors of the stars, matter may exist in forms with which we are not familiar. There, it is probable that the atoms are all stripped down to their innermost orbits, that is down to the K rings. It might be supposed that even these would be removed and that matter would exist merely as individual protons and electrons, but calculation indicates that even these super-enormous temperatures of 40 and 50 million degrees are unable to strip the K rings from the atoms.

Now, it may well be asked what these considerations have led to; we have explained the stability of the atom and the universe on the basis of the quantum law but we also have assumed that the radiation from the sun and stars is a consequence of the annihilation of the atom. How can these inconsistent views be correlated?

This is a difficult question; but the suggestion has been advanced that perhaps the annihilation of atoms under certain conditions is spontaneous, just as the disintegration of radioactive atoms is spontaneous. The disintegration of the atoms of a radioactive substance, it will be recalled, proceeds regularly regardless of anything we can do to prevent it or accelerate it. Each instant, a certain definite percentage of the total number of atoms in a mass of radioactive material become unstable and disintegrate.

Similarly it may be that under the conditions existing in the stars, where matter exists in states different from anything we are familiar with, the annihilation of atoms is spontaneous and of the total number present in a given mass, a certain definite percentage are destroyed each instant. In other words, such spontaneous annihilation is the natural course of events for such atoms and sooner or later all will meet this fate.

CIRCULATING WATER leaking from the water side of the condenser contaminates the feedwater and builds up an erratic boiler water concentration which is difficult to control. This often results in carryover of the boiler water containing salts which cause scaling and burning out of the superheater elements, scouring of pipe bends and even corrosion or coating of the turbine blades which in turn lower the efficiency and increase maintenance.

Rock Island Hydroelectric Development

ROCK ISLAND hydroelectric power development on the Columbia River, Wash., 13 mi. downstream from Wenatchee, consists of a low-head type of development which is little more than a concrete slab in the river bottom on which rests a series of piers, completed by gate-controlled spillways designed so that the river can be controlled up to 530,000 cu. ft. per sec.

The project is being constructed for the Washington Electric Co., a subsidiary of the Puget Sound Power & Light Co., Seattle, Wash.

Cost of the four units to be ready for service in August, 1932, and foundations for a total of 10 similar units, with the possibility of adding two more, will be $13,000,000. Total cost of the ultimate development will be, for 12 units, $28,000,000. Four units of 21,000 hp. each or 84,000 hp., are to be ready for service August, 1932.

ROCK ISLAND AS IT IS EXPECTED TO APPEAR WHEN FINISHED IN 1932

The dam, including the power house, and both spillways is 4400 ft. long, 108 ft. high, with tiers 40 ft. high and about 40 ft. apart. Between Rock Island and power house, a gate-controlled spillway section, about 550 ft. long, will be equipped with nine crest gates 30 ft. wide by 18 ft. 6 in. high and six gates 30 ft. wide by 41 ft. high.

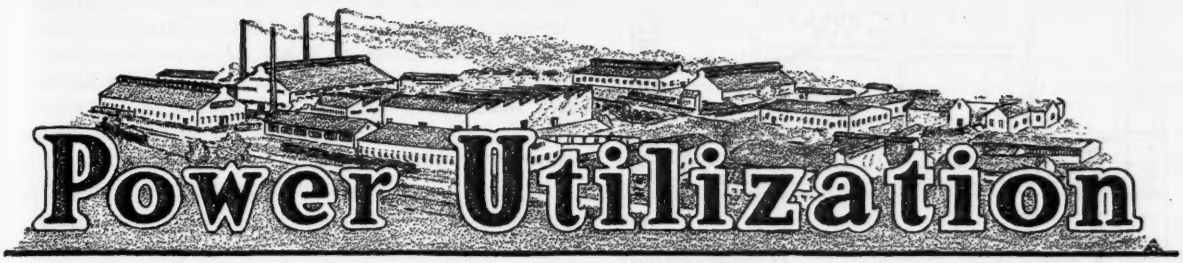
The dam in the west channel of the river will be 825 ft. long, a gate-controlled spillway, equipped with 10 crest gates 30 ft. wide by 18 ft. 6 in. high, and 10 crest gates 30 ft. wide by 41 ft. high.

The power house will contain four units in initial development, each of 15,000 kw. capacity, with provision for 10 such units. Two more units are to be used only for secondary power, making a total available primary and secondary power in the Rock Island development of 180,000 kw. or 240,000 hp.

Four initial water wheels will be 21,000 hp. each. Generators, 16,667 kv-a. each, operate at 100 r.p.m. Under higher flows the head on the wheels is somewhat diminished, therefore, the wheels are designed with adjustable runner vanes.

Power from the Rock Island development will be sold by the Washington Electric Co. to the Puget Sound Power & Light Co. and distributed through its system by four 110-kw. transmission lines, each 125 mi. long.

Rock Island development is under the direct supervision of W. D. Shannon, manager in the Northwest for Stone & Webster Engineering Corp., with headquarters in Seattle. R. E. McGrew is superintendent of construction at Rock Island and T. H. Campbell, superintendent of construction of transmission lines.



Machine *and* Conveyor Drives *in a* Sugar Mill

By DAN GUTLEBEN

SPECIAL GEAR, CHAIN AND BELT ARRANGEMENTS. ELEVATOR HOUSINGS AND TAKE-UPS

A GEARED reciprocating pump that handles heavy, stubborn syrup had its countershaft geared to the motor. As gears, motor and pump suffered frequent damage, the motor was raised on a steel support erected on the pump frame, Fig. 1, and connected by a short-center belt and idler and no further trouble was had with this pump. This pump requires 8 hp. and pumps 170 g.p.m., which capacity is satisfactory. For emergency, a direct-connected centrifugal pump was used, which required 58 hp. and delivered the syrup at 570 g.p.m. The geared pump for this job is, of course, much more efficient than the centrifugal.

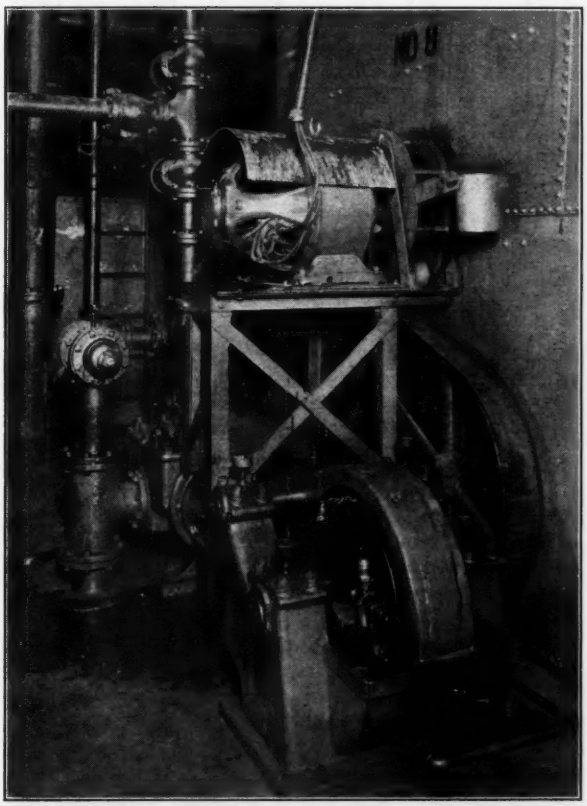


FIG. 1. GEARED MOLASSES PUMP WITH MOTOR DRIVE

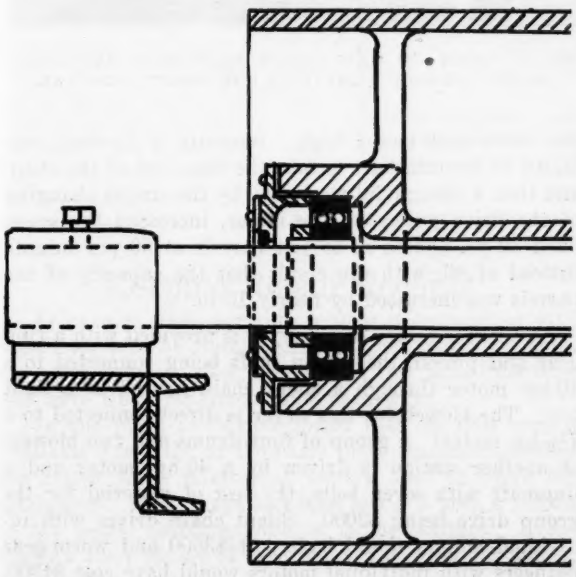


FIG. 2. BALL BEARING IN FOOT PULLEY FOR BELT CONVEYOR

Four water pumps that belong to one system and must always run together are joined end to end with flexible couplings and driven by one motor on one continuous home-made base. The long row of sewing machines, for repairing jute bags were originally belted to individual ⅓-hp. motors running at 2400 r.p.m. A single motor at 850 r.p.m., direct-connected to a ball bearing lineshaft located under the table, now drives these with a great saving in upkeep.

For foot pulleys of belt conveyors, the ball bearings are installed in the hub so as to avoid the necessity of ball and socket housings in the take-ups, Fig. 2. This makes a very simple take-up. In the case of foot pulleys for refined sugar elevators, where it is necessary to avoid oil contamination, the split pulleys are mounted on a cold-rolled steel quill, the ends of which are carried outside of the elevator housings, Fig. 3. The boxes to carry the bearings are enlargements made of steel tubes welded to the quill and machined to fit the bearings. The take-up is merely a threaded rod passing through

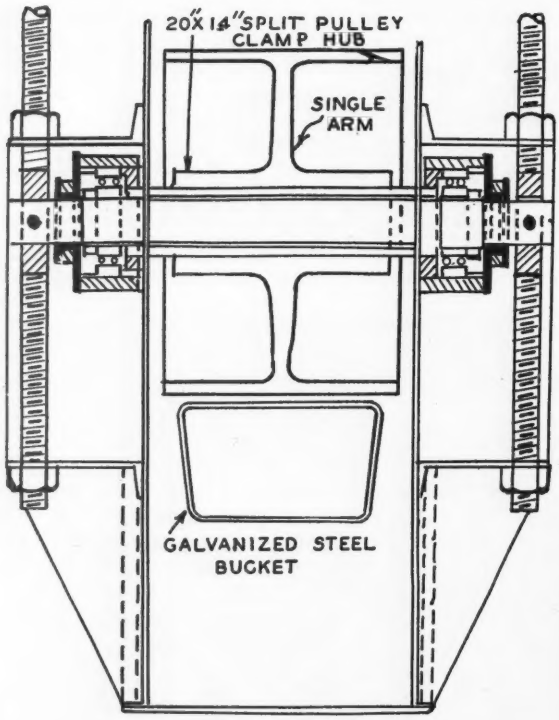


FIG. 3. OIL-TIGHT FOOT SHAFT FOR REFINED SUGAR CONVEYOR

the shaft ends. For jobs of this kind, bearings with self-alining features are preferred, as otherwise the machine work would have to be precise, which is not economically possible in an ordinary maintenance shop, especially as a second set-up is required in case the two bearing housings cannot be bored in one continuous operation.

FIG. 4. WORM GEAR DRIVE FOR BELT CONVEYOR

Where compactness is required, as for small portable conveyors and bag pilers, worm-gear reducing sets, Fig. 4, are used with the worm wheel shaft extended to serve as head shaft while these are of high first cost, no repair expense has been incurred in 6 yr. operation.

For the foot shaft on raw sugar elevators, which must, at times be cleared out, the shafts are brought out through removable doors to bearings carried on I-beam frames. Take up is by means of screw rods from the ends of the I-beams as seen in Fig. 5. This allows of easy dismantling and removal of the shaft from the elevator casing for cleaning or for repairs to elevator chains or buckets.

Recent installations of compressors use Texropes. with idlers. In the case of compressors with automatic control, the idlers jump, if the start is sudden and, in one case, an arm has broken off. The short-center leather belts driving vacuum pumps are giving long and satisfactory service. The camshaft of a row of barrel shakers is driven by a 1-in. pitch steel roller chain for the first reduction, followed by a short-center leather Their first cost was about equal to good leather belts with idlers. This shaft was originally driven by a back-geared motor. The pulsations made the upkeep on

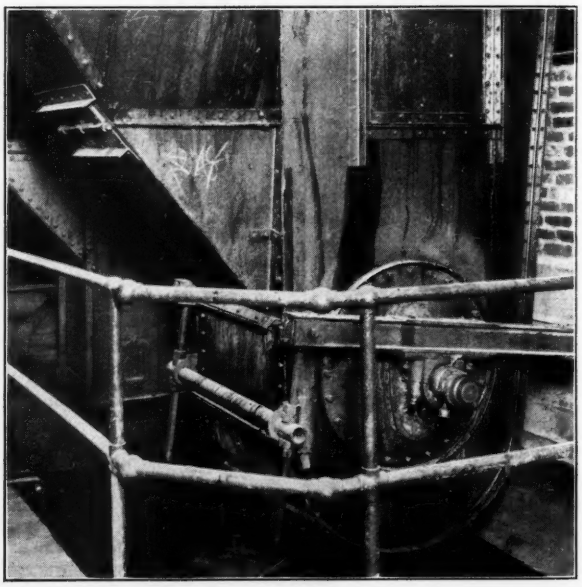


FIG. 5. FOOT OF RAW SUGAR ELEVATOR HAS HOME-MADE TAKE-UP ALSO DOOR FOR SHAFT REMOVAL

the drive and motor high. Recently a flywheel was added to the camshaft to take the whip out of the chain and then a thoughtful mechanic, by the simple changing of the drive pulley on the motor, increased the speed fixed 30 yr. ago so as to jolt barrels at 50 per minute instead of 40, with the result that the capacity of the barrels was increased by nearly 10 lb.

A six-foot rotary drum dryer is provided with a ring gear and pinion, the pinion shaft being connected to a 10-hp. motor through a silent chain housed in a tight box. The blower for this dryer is direct connected to a 7½-hp. motor. A group of four drums and two blowers at another station is driven by a 40-hp. motor and a lineshaft with seven belts, the cost of material for the group drive being $2000. Silent chain drives with individual motors would have cost $3600 and worm-gear reducers with individual motors would have cost $4300.

For a special purpose about a hundred 24-in. belt

troughing idlers were needed. The space limitation required these to be not more than 3 in. in diameter. The rollers, Fig. 6, were made of cold-rolled tubes into the ends of which were pushed hubs made of scrap shaft ends. These hubs carry ball bearings sealed with dust washers by the makers. As the boring of the ends may not be perfectly concentric, loose-fitting bearings are used to provide for misalinement.

one set of spare parts would care for breakdowns on several machines.

Instead of merely the nameplate reading, the motor card index eventually carried the following information:

Pulley diameter: Material, bore, key way.

Gear: Material, pitch, number of teeth, face, bore, key way.

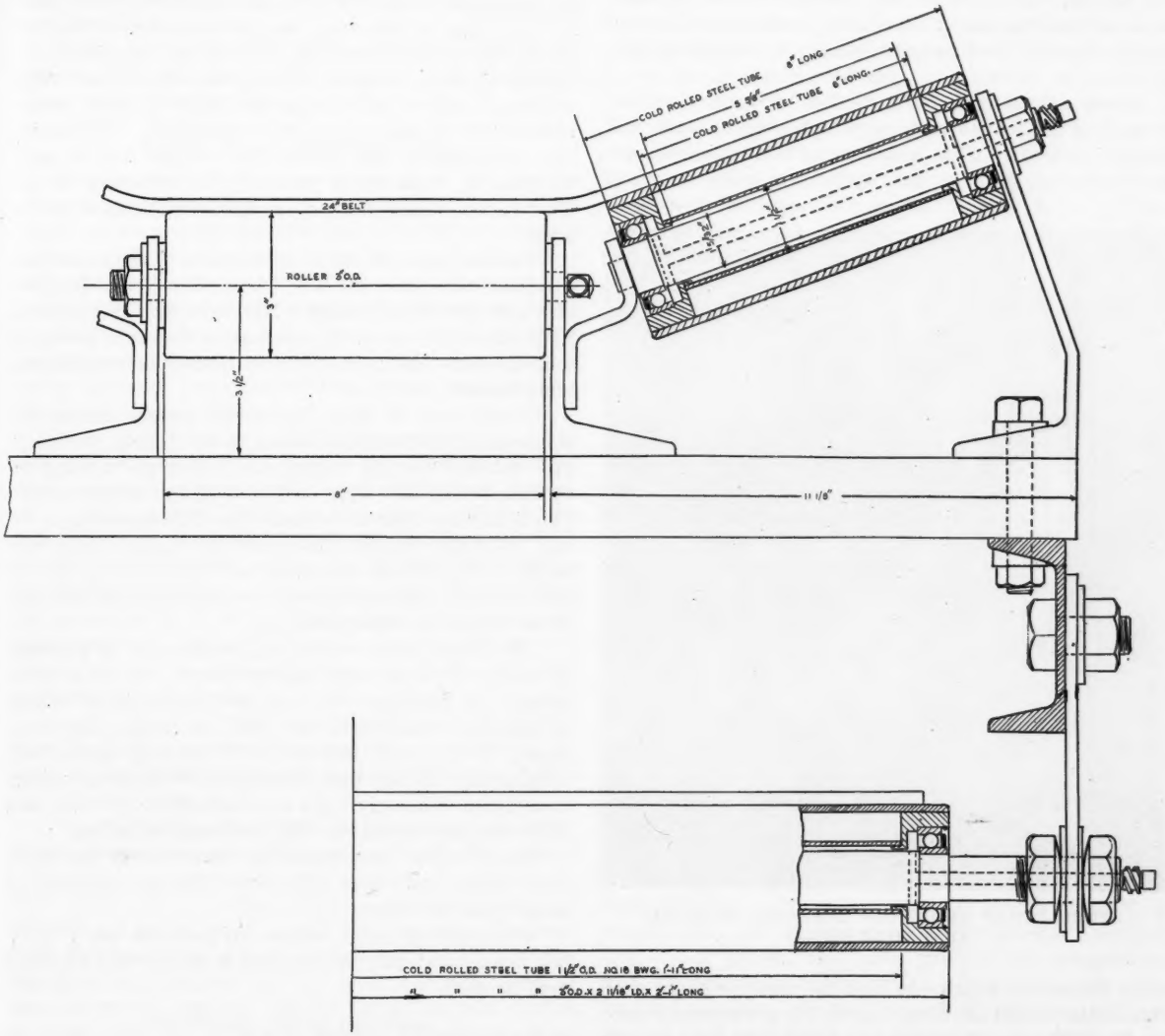


FIG. 6. BALL-BEARING TROUGHING ROLLERS FOR BELT CONVEYORS

Keeping Repair Records

IT PAYS TO KEEP accurate records in connection with repair work. The more carefully these records are kept, the more valuable they become and the more time they will save when repairs become necessary.

In one plant the writer found that the only record available was a list of the name plate readings covering the rather large number of motors used to drive the machinery. No attempt had been made to keep a record of the gears, shafting, pulleys, motor starters. Eventually a complete set of card indexed records was added, which saved much time in checking spare parts. Also it was possible to standardize a number of items so that

Size and number of brushes, grade, length of pig tail.

Distance between holes in base of motor.

Height from bottom of motor legs to center of shaft.

Whenever a motor was rewound, complete data covering the coils and connection were entered on the card covering this particular motor. All machinery in the plant was numbered and all spare parts for any machine were tagged and carried the same number as the machine that they would fit.

Cold Spring, Minn. CHAS. A. PETERSON.

Defects in Motor Windings

Locating Grounds and Short Circuits.

By A. C. Roe*

DEFECTS likely to occur in motor or generator windings make their presence evident in various ways, depending upon the type of apparatus and the defect. In the majority of cases, the trouble requires the shutdown of the equipment, to permit locating and correcting the defect. The major problem is to find the location and kind of defect.

Some defects are easily located by inspection, but those that are invisible and require testing to locate will be given attention, as it is important to be able to locate and correct speedily a minor defect, or to detect it and

STEEL STRAP VIBRATION TEST FOR SHORTED ARMATURE COILS

make temporary repairs, to keep the machine going until conditions permit shutting it down for permanent repair.

Most common of defects is a ground in some part of the winding. If applying test voltage shows no flashing or smoking, on a.c. windings, separate the phases and locate the grounded phase. The grounded coil can then be located by elimination, i.e., isolating one pole phase group at a time; when the grounded group has been located, test out the individual coils in that group until the grounded coil is located.

After locating the grounded coil, it is necessary to find the defective spot. If when lifting the top half of the coil out of the slot, the ground is still present, it is in the bottom of the slot. In this case, the condition of the winding and urgency of the case determine whether to repair by cutting out the coil or by stripping and rewinding the stator.

*Renewal Parts Engineering Dept., Westinghouse Elect. & Mfg. Co.

Magnetic Wedge Motors

One type of ground common to a.c. motors that have the metal or magnetic wedges manifests itself in causing the winding to heat up. In some cases, where a large number of the wedges are grounded, the motor will attain high temperatures in 2 or 3 hr., and, unless shut down, the windings will burn out.

If, therefore, a motor persists in heating up, and investigation reveals no overload or shorted coil, check the windings to determine whether the iron or the coils is the hotter. If the iron is heating up, check for grounded metal wedges. Then, if the motor has metal wedges, it will be safe in the majority of cases to substitute fiber wedges, in one of the windings. This means that, for squirrel cage motors, fiber wedges can be used, whereas in wound-rotor motors it is preferable to use fiber in the stator and retain the metal wedges in the rotor.

Various types of metal or magnetic wedges used are insulated from the core and, if this insulation deteriorates and allows the wedges to short the core laminations, eddy currents are set up, increasing the core losses, so that in some cases, the iron is heated to troublesome temperatures.

Substitution of fiber for metal wedges affects the magnetizing current, iron losses, power factor, efficiency, pull out and starting torque, the difference varying according to the size, type, age and design of the motor. The following figures indicate the differences on a 40-hp., 3-phase, 4-pole, 60-cycle, 1800-r.p.m. induction motor. Figures are given in per cent increase or decrease of the various factors, when substituting fiber for metal wedges on that motor.

(1) Magnetizing current, approximately 20 per cent increase; (2) iron losses, approximately 94 per cent increase; (3) reactance in ohms per phase, approximately 10 per cent reduction; (4) pull out torque, approximately 15 per cent increase; (5) starting torque, approximately 34 per cent increase; (6) full-load power factor, approximately 1 per cent reduction; (7) full load efficiency, approximately 3½ per cent reduction.

Many motors are operating satisfactorily in which fiber wedges have been substituted for the magnetic or metal type of wedge.

When testing metal wedges for grounds, use a 110-v. test lamp which can also be used to locate coils having a dead ground.

Grounds in D.C. Machines

In d.c. machines it is more difficult to locate the place where one or more coils are grounded. The first question is whether the commutator or winding is grounded. Unless the flash or smoke shows up the ground, assume that the winding is grounded and, with as low a voltage as will indicate the ground, proceed to isolate the grounded coil.

It is well to determine whether the armature has a lap or wave winding, as, with a lap winding, it is possible to sectionalize the winding by lifting a few top leads at regular intervals around the commutator. With a wave winding, as many coils are in series between adjacent bars as there are pairs of poles. On a wave winding, lifting a few top leads at different spots around the commutator will sectionalize the winding but, to be sure that the grounded coil is located, both leads of the one

coil must be found and the series of coils disconnected. After finding the grounded coil, remove its leads from the commutator and test the commutator to be sure that the ground is in the coil and not in the commutator.

If the ground is in the half of a coil in the bottom of a slot, the defective coil can be cut out by disconnecting both leads. On wave windings it is best to use a long jumper, back of the commutator necks, connecting together the bars to which the leads of the defective coil were connected.

When cutting out coils on d.c. or a.c. machines, the coil should be cut open at the rear end to prevent short circuit in the cut-out coil.

Shorts in and Between Coils

A short-circuited turn or turns in a coil can be detected by the temperature it attains but, when a short occurs between adjacent coils, between top and bottom layers of coil ends or leads, or between top and bottom coil halves in the same slot, it takes skill, experience and a thorough knowledge of the type of windings to locate the defect quickly. A wave winding introduces more complications, due to the series of coils connected between adjacent commutator bars, hence requires considerable skill and patience.

On a.c. lap windings, if feeling for the hot coil or coils does not locate the defective coil, open the star or delta connections and check for short between phases. If between phases, follow the two phases through the pole phase groups, isolating each pole phase group, until the trouble is located, which on distributed windings may be in the slot where the phase belts overlap. This can be located by isolating the single coils in each group until two coils, one in each pole phase group, show a short. Lifting the top half of one coil should clear the short and permit repairs.

When a short is between layers of coil ends, it will show up similar tc shorts between phases or coils in the same slot and the process of isolation will soon locate the defective area.

Wave windings, when used in either rotor or stator of a.c. motors, are generally composed of strap copper coils having one, two, three or more turns and short circuits occur between adjacent turns, between phases, or between the layers of coil ends. But the wave windings used with induction motors are divided into six sections, therefore, by opening the star and reversing jumper connections, we have six isolated parts. In each section as many coils are in series between adjacent leads as there are pairs of poles; thus, starting at one lead of a section, the winding will progress around the armature, passing through as many coils as there are pairs of poles, before ending one strap behind the lead started on. The number of times that one can pass around the winding before ending the section depends upon the turns per coil times the number of slots per pole per phase.

With wave windings applied to d.c. machines, the coils will be one of many types and trouble can occur as mentioned for a.c. wave windings, between phases on rotary converters. It should be remembered that, when testing any wave winding between two adjacent bars or leads, a series of coils is under test.

Two methods are commonly used for testing lap or wave-wound rotors or armatures for short circuits. The first is the growler test as shown, where the operator is using a strip of steel to bridge the slots. A short circuit will cause the steel to vibrate and knowledge possessed by the operator regarding the principles of the various windings will enable him to locate the defect speedily.

The second method is called the bar-to-bar test, using a suitable variable current supply and a volt or millivoltmeter. Current is adjusted to give a readable deflection on the meter scale and readings taken between adjacent bars. Both methods can be applied to a.c. or d.c. rotor or stator windings.

For those who wish to study further the details of how the various defects show up on different types of windings, the following books will be found helpful: Connecting and testing d.c. machines, by Annett & Roe; connecting induction motors, by A. M. Dudley; armature winding and motor repair, by Braymer; rewinding small motors, by Braymer & Roe.

A. S. R. E. Meets at Kansas City May 6 to 8

Air conditioning, quick frozen foods and other new developments which provide the field of refrigeration with unlimited opportunities for new markets will be covered in the varied program arranged for the 18th Western meeting of the American Society of Refrigerating Engineers, which is to be held May 6, 7 and 8 in Kansas City, Mo., with the K. C. Athletic Club as headquarters. The series of talks planned, together with the social program arranged by the local Kansas City committee under the direction of E. M. Dodds, indicate that the meeting will be most successful, according to the announcement.

All the talks for the first session, at which A. H. Baer, president of the A.S.R.E., will preside, are on new industrial applications of refrigeration, including air conditioning, oil refining, the design of drinking water systems, management control for large groups of ice plants and bakery refrigeration.

At the second session, over which Glenn Muffly, vice-president of the Society, will preside, all the papers will be concerned with commercial-domestic machinery. Practical subjects such as the control of brines and refrigerants, the use of paper as a refrigerator insulant, evaporator design, the noise problem in compressors, and low temperature test rooms, will be featured. New thermal problems are the general subject for the third session, and here again the subjects to be discussed are particularly timely—chemistry in food freezing and cold storage, ice melting rates, and carbon dioxide ice.

Social program includes an automobile tour over the Kansas City boulevards, a stag smoker followed by a buffet supper, a ladies' luncheon and bridge at the Indian Hills Club, and a banquet followed by special entertainment and dancing.

Application for reduced railroad fare has been made, and the certificates will be circulated to all those receiving notices of the meeting. A special train for members from New York, Philadelphia, and Pittsburgh will leave New York the Monday before the convention, going over the Pennsylvania to St. Louis and on by the Missouri Pacific, and an official train for the Chicago and Milwaukee Section will leave Chicago over the Santa Fe at 9:05 the night of May 5.

Calculating Steam Pipe Sizes

NOMOGRAPHIC CHARTS for the solution of the Babcock Formula have been utilized by me during the past eight years so that the article entitled Calculating Steam Pipe Sizes and Pressure Losses appearing on page 8 of the January 1 issue, was of considerable interest to me. The prints, Figs. 1 and 2, show my solution of the above formula, Fig. 1 solving for the pressure drop and Fig. 2 for the velocity. These charts are simpler than those published with the previous article and are devised as follows:

The original Babcock formula is,

$$w = 87 \left[\frac{pyd^5}{\left(1 + \frac{3.6}{d}\right) L} \right]^{\frac{1}{2}} \qquad 1$$

Where w = the weight of steam flowing in lb. per min.
p = the difference in pressure between the two ends of the pipe in lb. per square in.
y = density of the steam, or weight per cu. ft.
L = length of the pipe in ft.
d = internal diameter of the pipe in in.

Letting L = 100 ft. and W = the weight of steam flowing in lb. per hour; and

$$K = \frac{d^5}{1 + \frac{3.6}{d}},$$

Eq. 1 becomes on rearranging

$$Wy^{-\frac{1}{2}} = 522\, p^{\frac{1}{2}} K^{\frac{1}{2}} \qquad 2$$

Equation 2 is arranged in the proper order for nomographic plotting, since W, the weight of steam and y, its density (which is a function of the absolute pressure), are most generally the two known quantities, the combination of which gives a fixed point on the dummy line. From this fixed point, an infinite number of combinations of p, the pressure drop, and K, a function of the diameter of the pipe, can be obtained.

Actual plotting is done as follows: Referring to Fig. 1, the logarithms of W are plotted directly since W ap-

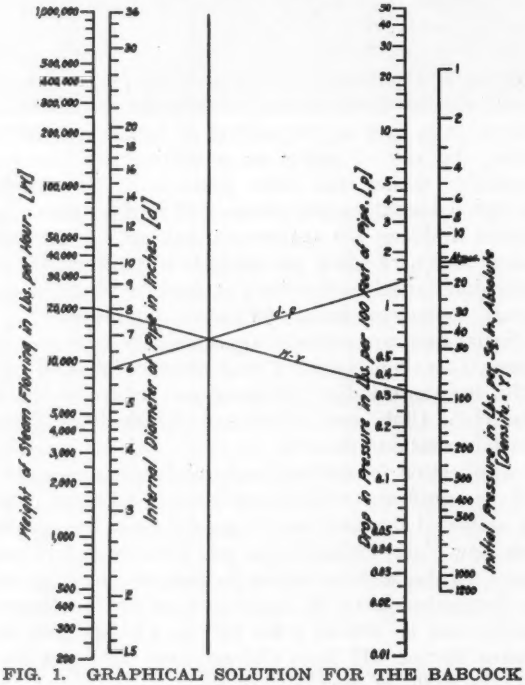

Height of Steam Flowing in Lbs. per Hour. [W].
Internal Diameter of Pipe in Inches. [d].
Drop in Pressure in Lbs. per 100 Feet of Pipe. [p].
Initial Pressure in Lbs. per Sq. In. Absolute (Density: y)
d-p
K-y

FIG. 1. GRAPHICAL SOLUTION FOR THE BABCOCK FORMULA

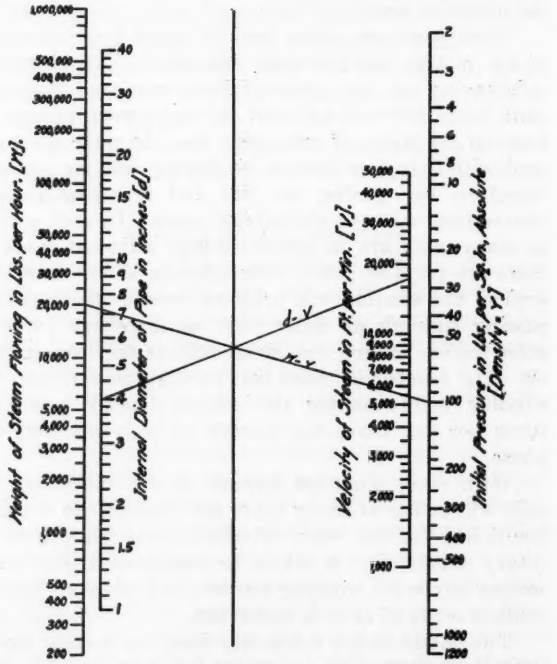

Height of Steam Flowing in Lbs. per Hour. [W].
Internal Diameter of Pipe in Inches. [d].
Velocity of Steam in Ft. per Min. [v].
Initial Pressure in Lbs. per Sq. In. Absolute (Density: y)
d-v
K-y

FIG. 2. CHART FOR DETERMINING STEAM VELOCITIES

pears as a direct function in the equation. The pressure in pounds per square inch, absolute, is obtained by plotting the logarithm of the density y, which corresponds to the given pressure. Since y has a negative exponent, the scale will be inverted. By the proper selection of scales, the dummy line can be located midway between the two nomographs, but it is preferable to select scales which will give as wide graduations as possible within the limits desired and let the dummy line fall where it may.

Having determined the W and y nomographs, also the location of the dummy line, the d and p nomographs can be plotted. The pressure drop p, being a direct function, can be plotted proportional to its logarithms, but d must be plotted proportional to the logarithms of the corresponding values of K. Since the location of the dummy line is already fixed, the nomographs of p and d must be plotted to the same scales as were those of W and y; also the moduli must be equal or proportional to those already determined for W and y.

The formula for the velocity is

$$W = \frac{0.327d^2v}{V} \qquad 3$$

Where W = the weight of steam flowing in lb. per hr.
d = internal diameter of the pipe in in.
v = velocity in ft. per min.
V = specific volume.

Again putting $y = \frac{1}{V}$, Eq. 3 becomes

$$\frac{W}{y} = \frac{vd^2}{3.06} \qquad 4$$

Actual plotting of 4 shown in Fig. 2, is practically the same as that of Eq. 2 given above. In this case, however, it is advisable to vary the scales and moduli somewhat in order to obtain sufficiently wide graduations for v so as to insure reasonable accuracy.

Plotting of the Fritzsche Formula can be done in exactly the same manner as that of the Babcock Formula described above. Advantages of the above method of plotting are twofold: By using the absolute pressure rather than the density or specific volume, all pipe calculations involving the flow of saturated steam, can be solved without recourse to steam tables and as about 90 per cent of all pipe calculations involve saturated steam, a great deal of time can be saved by this method; By folding the plotting and using only one dummy line, a nomographic chart can be made which will have fairly wide graduations, reasonable accuracy, and yet small enough to be plotted on an 8½ by 11-in. standard notebook sheet.

Dayton, O. W. I. Barrows.

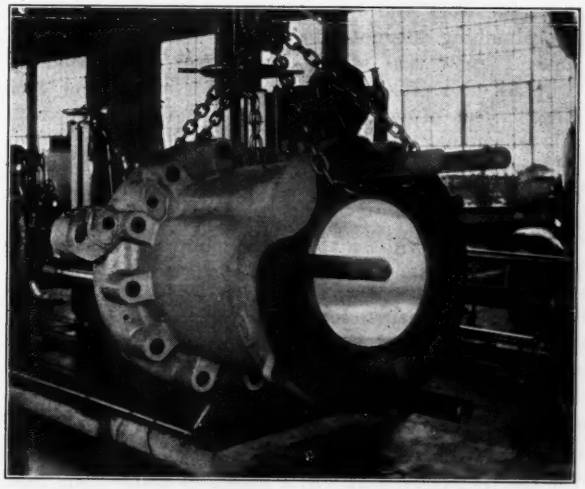
Ground Cylinder Versus Bored Cylinder

Wide observation of engine repair practice in the Southwest among oil and gas companies operating thousands of engines, shows a distinct preference for the ground cylinder. It appears that from every point of view the ground cylinder for gas and oil engines is far superior to cylinders bored with a cutting tool. All shops engaging in this work are equipped for grinding instead of boring and all cylinders leaving these shops are ground.

Experience shows that the period of service (between grindings) rendered by the ground cylinder is greater than that between borings and is due solely to the superior service and wearing qualities of the ground cylinder.

When bored with a cutting tool, the cylinder starts its period of service with a minutely corrugated surface which must be worn to a glaze by the friction of the piston and rings. On the other hand, the ground cylinder begins its period of service presenting its full surface area in contact with the piston and rings.

In the ground cylinder, this desirable glazed surface is produced by the grinding wheel, not by frictional wear as in the bored cylinder and it is this same friction



GROUND CYLINDER SHOWING POLISHED SURFACE BEFORE BEING PUT INTO SERVICE

which has a tendency to cause excessive heat and destroy the lubricant.

Excessive heat and lack of lubrication are the usual causes of scored cylinders and cracked pistons.

Clearance between the ground cylinder and its piston remains the same until natural wear gradually increases it, while the clearance between the bored cylinder and its piston increases rapidly until the corrugations are worn off and the glazed surface is formed by natural wear.

Accurate measurements of a cylinder carefully bored with a tool and then ground show that the diameter increases at least 0.004 in. before the proper glazed surface is obtained, proving that the bored cylinder loses its economy much sooner than the ground cylinder.

When a repaired cylinder is installed in the field, it is necessary with the bored cylinder to spend some time "running in" this cylinder to prevent piston seizure, whereas with the accurately ground cylinder, this risk is eliminated and the cylinder is capable of taking the load immediately without the slightest chance of danger from seizure.

Dallas, Tex. Orville Adams.

Quick Freezing for Pipe Repairs

CONSIDERABLE interest and some surprise on my part were occasioned by the article Quick-Freezing of Pipes for Repairs on page 345 of the March 15 issue. The cause of my surprise was the statement that cast-iron water pipes had been frozen without cracking the pipe. I have seen the method of freezing stationary water in steel, wrought iron and lead pipe done without visible injury to the pipes but only on pipes of ½ to 2 in. in diameter. Although no injury is visible, I doubt the possibility of solidly freezing the water in a 2-in. wrought iron or steel water pipe without weakening the strength of the pipe at the point frozen. A solid plug of ice some inches long must be formed and the expansion across the diameter will be considerable. The smallest diameter of cast-iron water pipe in general use is 2 in. and I doubt the wisdom of attempting such a risky scheme as freezing except in a case of extreme necessity.

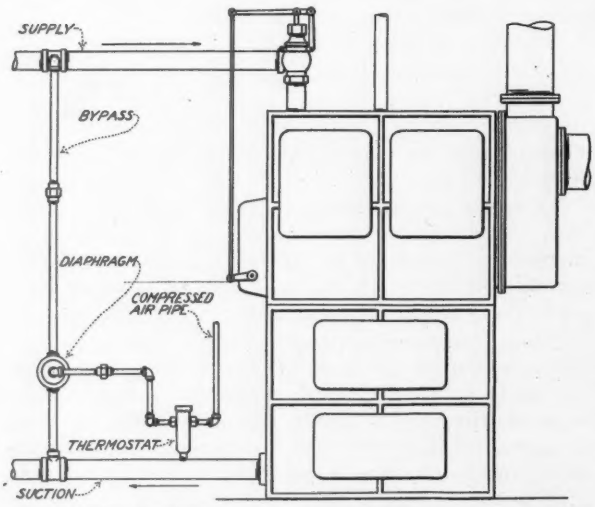
For more than 30 yr., I have been connected with iron pipe work and I have relatives who have been in the plumbing business for about the same period of time; I know that seldom is the freezing method attempted. No pipe can be frozen if any valve or cock allows a leak of even a quick drop. A lot of talk about this scheme has appeared in the past but I feel that it is seldom attempted, for in nearly every case some way can be found for checking the flow of water on the pressure side.

A problem will usually be encountered in checking all leakage on the discharge side, a necessary condition before success is possible by the freezing.

Toronto, Can. JOHN THORN.

Device for Condensing Vapor in Feed-Pump Suction

LACK OF sufficient headroom in the space available for the feedwater heater in a basement boiler room compelled setting the heater so that its outlet was on a level with the feed pump's suction inlet. As a result, the feed pump did not work well. A heater temperature of 210 deg. could be easily obtained. For a pump to handle water at this temperature, the suction should flow under a head sufficient to overcome the pump's tendency to become vapor-bound. Setting the pump so that its suction inlet would be in a place at least 5 ft. below that of the heater's outlet would provide the necessary head.



AUTOMATIC DEVICE FOR PREVENTING STEAM BINDING FEED PUMP

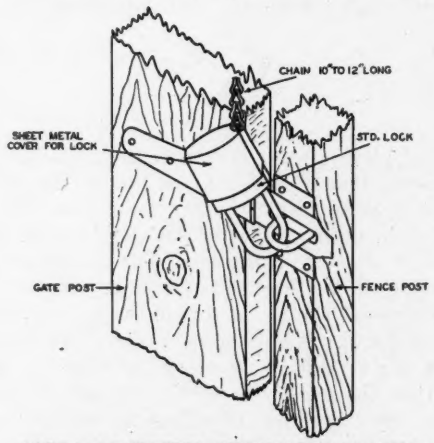
To keep the feed pump from becoming steam-bound, it was arranged to condense the vapor by injecting an occasional dash of cold water into the suction pipe. The accompanying sketch shows how this was accomplished. When the temperature of the suction water rose to about 205 deg., the thermostat inserted in the suction pipe operated to admit compressed air above the diaphragm attached to the stem of the valve in the bypass pipe. Opening of the bypass valve in this manner permitted a current of cold water to enter the suction pipe and condense any vapor forming therein. When the temperature of the suction water had dropped a few degrees, the thermostat released the air from above the diaphragm and the valve was closed by the tension of a coiled spring beneath.

Intermittent injection of cold water into the suction pipe in this manner gave an average temperature between 200 and 205 deg. to the water entering the pump cylinder, even though the heater temperature had risen to 210 deg.

St. Louis, Mo. D. J. ALTIZER.

Outside Locks Made Sleet-Proof

IN THE NORTH, where ice and sleet are so prevalent in winter, it is necessary that locks used on the gates of isolated substations, pole tops, switches, etc., be protected from ice and sleet in order that they may be opened quickly in case of emergency.



COVER PROTECTS KEYHOLE OF LOCK

Reproduced herewith is a sketch showing a simple method adopted by a power company operating in the Northwest and although simple, it is quite effective. All locks in use are identical in design and size. A sheet metal cover slips over the lock as shown and is supported by a piece of chain which is fastened to the gate or pole so the lock always remains so the key hole is on the upper side and rain cannot enter the lock. Obviously, the inside of the lock is always dry and the key hole can never become ice coated.

This device would be equally valuable in dry, arid sections of the country where sand storms occur frequently.

Cold Spring, Minn. CHAS. A. PETERSON.

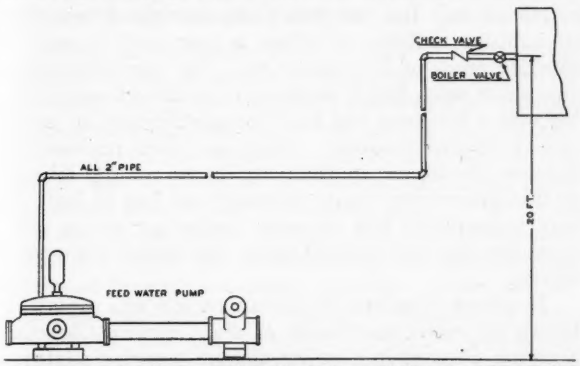
Questions and Answers

Water Hammer in Feed Line

WATER HAMMER occurs in our feed line between the boiler feed pump and the boiler inlet. This line consists of about 60 ft. of 2-in. pipe and is equipped with boiler valve and check valve 2 ft. apart as shown in the illustration. The boiler inlet is about 20 ft. higher than the pump, which is of the single cylinder horizontal type.

What is the cause of this hammering and how may it be overcome? E. C. D.

A. Water hammer consists of a series of hammer-like blows due to the shock of suddenly checked flow of water in a pipe. If a valve is suddenly closed, the



LAYOUT OF PIPE CONNECTIONS SHOWING RELATION BETWEEN FEED PUMP AND BOILER VALVES

kinetic energy of the arrested column of water is expended, if no relief devices are provided, in compressing the water and in stretching the pipe walls. Starting at the suddenly closed valve, a wave of increased pressure is transmitted back through the pipe with constant velocity and intensity. The shock pressure is not concentrated at the valve but if a bursting pressure is produced, it may show its effects near the valve simply because it acts there first. The velocity of the pressure wave for ordinary cast-iron pipe, 2 to 6 in. in diameter, is about 4200 ft. per sec.; for a 24-in. pipe it is about 3300 ft. per sec.; depending on the elasticity of the metal and upon the ratio of its thickness to the diameter of the pipe. If the pipe were perfectly rigid the velocity would be that of sound through water, about 4700 ft. per sec.

Increase of pressure is proportional to the destroyed velocity of flow and to the speed of propagation of the pressure wave. This increase is about 60 lb. per sq. in. for each ft. per sec. of extinguished velocity for 2 to 6 in. pipes and about 45 lb. per sq. in. for each ft. per sec. for 24-in. cast-iron pipe. These increases of pressure will be attained only in case the valve is closed in less time than one round trip of the pressure wave.

When the pressure wave has travelled upstream to the end of the pipe where there is a reservoir or a larger main, the whole pipe then being under increased pressure with checked flow throughout, the elasticity of the compressed water and that of the distended pipe reverse the flow at that end of the pipe and a wave of normal pressure, that of the reservoir or main, travels downstream, the flow being progressively reversed as the compressed water expands. When this wave of normal pressure reaches the valve, the kinetic energy of the column of water with reversed flow tends to create a vacuum at the valve. There the reversed flow is checked and the checking proceeds progressively upstream accompanied by a wave of sub-normal pressure.

When this wave reaches the upstream end, the whole pipe then being under subnormal pressure, the greater normal pressure in the reservoir or large mains starts flow into the pipe and a wave of normal pressure and forward flow travels downstream. When this wave reaches the valve there is forward flow throughout the pipe, the conditions being the same as when the valve was suddenly closed and a wave of increased pressure and of checked flow again starts upstream. A complete cycle of pressure waves and reversals of flow occupies the time required for two round trips. The amplitude of the pressure vibrations becomes less with succeeding cycles because of friction but the time interval remains constant.

If a high-pressure wave, in its travel through the pipe, enters a branch pipe with a closed or "dead" end, there will be almost a doubling in the increase of pressure when the wave strikes the closed end.

Adequately proportioned air chambers on pumping mains and surge tanks on water-power supply pipes serve to absorb almost entirely the shock of water hammer. Means must be provided for replacing the compressed air in the air chambers as this is soon absorbed by the water. Relief or safety valves with adjustable springs are not so good for water-hammer shocks and are more likely to be out of order.

Acid Used to Clean Injectors

GIVE A simple method for cleaning scale from an injector? R. B.

A. To remove a coating of scale of carbonate of lime from the tubes of injectors, a mixture of muriatic acid and water in the proportion of one to five is effective. The acid acts but slightly on the bronze of the injector until after the scale is removed, so that it is safe to immerse the entire injector in the bath, removing immediately after the disappearance of the coating. The injector should then be rinsed thoroughly in water.

Removal of sulphate of lime is more difficult. Acids have little effect. Kerosene tends to loosen the scale by working through the interstices and over the metal surfaces, and this action is hastened somewhat by heat: the scale becomes broken and cracked and may then be chipped off.

Editorial Comment

Natural Gas Developments

During the past five years there has been a tremendous increase in the mileage of natural gas lines in use in the United States. Without question this rapid development will have a profound effect upon the fuel situation in this country. Gas companies are being interconnected and operated much in the same way as the interconnected electric systems and doubtless within a few years the public will be referring to "super-gas" as it now refers to "super-power."

Size of natural gas lines has increased up to about 26 in. and their length up to about 1000 mi. Operating pressures as high as 600 lb. are used, permitting a flow as high as 200,000,000 cu. ft. per day through a single line.

Increased interest in gas transportation has been brought about primarily by the discovery of enormous gas fields in Louisiana, Texas and California. To transport this gas to a market, the pipe line seems to be the only method. The possibility of building these pipe lines of large steel pipe of great strength by welding in the field and of handling it with modern labor saving machinery, have reduced construction costs. In the industrial centers, potential markets have appeared that have attracted capital for the work.

Just how much gas is available is, of course, unknown, but it is estimated that one field in Texas alone contains enough gas to keep a line of 100,000,000 cu. ft. a day capacity operating for 300 yr. At present about 80,000 mi. of trunk natural gas lines are in use in the United States.

Solution of the power problem upon such a tremendous pipe line system demands engineering of the highest order. Pumping stations and compressor stations sometimes use steam, Diesel or gas engines for power. The electric-motor-driven station under complete automatic control, taking its power from the transmission lines of public utility systems, gives promise of many interesting applications. One of the most ingenious pumping stations yet proposed (for a gasoline line) will contain centrifugal pumps driven by gas engines burning butane as fuel, the butane being sent through the line in liquid form. Some idea of the magnitude of these natural gas line operations will be gained from an article elsewhere in this issue describing two new compressor stations on a gas line in Kansas. The larger of these stations has a capacity of 41,000,000 cu. ft. of gas a day using six 1000-hp. gas-engine-driven compressors.

In the February 15, 1931 issue of Power Plant Engineering an editorial pointed out the possible effect of pipe line developments on the distribution of natural gas and of gas from coal treatment plants for use as boiler fuel. A paper by George Orrok at the Midwest Power Conference in Chicago suggested details of a power plant of the future which might burn gas and might involve in its design a combination of boiler and turbine room elements that are now available. In connection with Mr. Orrok's paper, it was brought out that complete gasification of coal is already being carried on, especially in England.

The entire engineering profession should be vitally interested in the natural gas development that is now going on. The final result of it will probably be, as usual, about half way between that expected by the general public, which is being told that gas is the new fuel of the future, displacing all other fuels and that hoped for by coal salesmen who cannot see how any fuel can possibly compete with coal.

Science and Lubrication

Paraffin wax, the most troublesome constituent of petroleum and the one which has cost the lubricating oil industry millions of dollars is now used to make a superior grade of lubricating oil. The new oils with a pale straw color, highly resistant to oxidation and sludging with a low pour test and low volatility can be made in any desired viscosity. They are more resistant to changes in temperature than any known natural oil and as this property prevents thinning and loss of body at high temperature and excessive thickening at low temperatures they are exceptionally well suited for severe service.

Synthetic chemistry of these new oils was explained before the recent convention of the American Chemical Society. Present lubricating oils are complex mixtures of hydrocarbons made from the heavier parts of petroleum after the gasoline and kerosene have been distilled off. These parts are then refined and refrigerated to remove undesirable constituents such as dark colored asphalts, petrolatum and paraffin wax.

Feeling that this was not the ideal lubricant, chemists of the Standard Oil Co. of Indiana worked for several years to determine what single hydrocarbon or narrow group of hydrocarbons made the best lubricant. They found that the ideal lubricant had molecules composed of two hydrogen atoms and one carbon atom. In the synthetic oils those having the carbon atoms arranged in chains are superior to those having the carbon atoms in the shape of rings or clusters.

In natural oils these desirable molecules appear in small proportion but cannot be separated from the less desirable ones. Further study showed that polymerization of hydrocarbons known as olefines gave the desired combination. Olefines are unsaturated hydrocarbons of the ethylene or $C_n H_{2n}$ series and polymerization is a reaction of two or more molecules of the same substance to form a compound from which the original substance can be regenerated and whose molecular weight is a multiple of the original compound.

Olefines of this type are rare and expensive but further research showed that after cracking, similar to modern gasoline production methods, paraffin yields the desired type and polymerization produces the new oils.

The Discipline of Designing

If the status of engineering education bears any relation to the practice of engineering at the present time, a curious engineer may be led to wonder what has happened to the design courses in a great many of our engineering schools. Competition among courses for a place in the curricula of modern engineering schools is almost as keen as the competition among industrial products. In the face of this competition, the general tendency has been to minimize and sometimes to eliminate design courses.

Leonard Doggett, writing of electrical design courses in the Journal of Engineering Education, says that he feels this is a mistake. He believes that scarcely a course in the curriculum can duplicate the advantageous features offered by a properly-taught design course. It is pretty generally agreed, however, that such courses should not and do not try to produce designing engineers. On the other hand, according to Mr. Doggett, the engineering graduate should have sympathy and appreciation for the problems of the designer and should have the point of view, that can be obtained only by carrying through complete designs.

A general philosophy runs through all designs; the economic factor is always present and the student is constantly face to face with hard realities. For example, the finished design proves to have too low an efficiency. What to do? The finished products, as designed, will cost too much. What to do? Space limitations, speed limitations, always some inescapable, physical fact to be considered in the design. Perhaps engineering judgment is the expression that best sums up the characteristic developed by proper courses in design. Numerical accuracy, a most important requisite in engineering practice of any type is fundamental in design. Construction details are best studied in design work. The difficulties of checking a tremendous amount of computation can be reduced materially by proper tabulation of results and these tabulations, over a period of years, constitute a most valuable accumulation of experience data, similar to the experience data always found in a commercial design office.

In engineering practice, the engineer is constantly faced with problems involving a set of physical facts and a set of commercial facts, both of which must be taken into account at the same time in the solution of the problem. Certainly, if it is possible to give the engineering student any help in developing the point of view from which such facts can be analyzed to produce the finished product, design courses in an engineering curriculum seem decidedly worthwhile.

Improved Plant Performance Available Through Chemistry

As the art of power generation approaches the limit of perfect efficiency, as established by present systems, engineers begin to look for revolutionary changes that will alter the entire practice of power generation. Rather than go dreaming of future accomplishments, the most sure and practical road to improvements is through the perfection of details which are known to be faulty, and none of the details about power plants are less understood than the chemical problems with which the industry is confronted.

During past generations, mechanical devices have been conceived and perfected to such an extent that, given a routine mechanical job, a device can be designed by a competent engineer to perform the work automatically. The laws of physics, as they enter into our daily work, are quite well understood. Even electricity, the newest branch of physics, is no longer the mystery it once was and for power purposes it does not withhold many secrets from the modern electrical engineer.

Hydraulics, pneumatics, thermodynamics, as employed in the generation and use of power, are well understood by competent engineers but the problems that are giving power plant engineers the greatest concern today are in the field of applied chemistry. Simple chemical reactions are easily understood and controlled but in nature chemically pure substances are almost never found and the engineer must deal with the materials available.

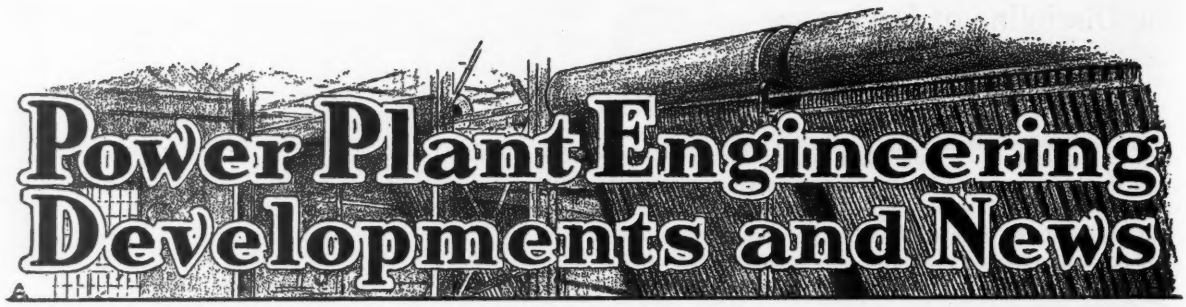
First in importance comes the problem of combustion. Fuel for steam generation, particularly coal, is notorious for its variety and percentage of impurities. Even the air used in the combustion process contains diluents and vapors in varying percentages that complicate combustion processes and the handling of the spent gases.

Feedwater and its complicated reactions during preliminary treatment and conversion into steam make a study which today challenges the best minds in scientific work. With all its complication, however, power plants must use feedwater whether or not the engineer understands the chemical reactions of his treatment. A more thorough understanding of feedwater chemistry will put an engineer in a better position to avoid dangers and increase economy than he could possibly do without this preparation.

Corrosion is another chemical problem, responsible for more deterioration about power plants than any other one chemical reaction, yet too little understood by men in the plant. Metallurgy, a branch of chemistry, is advancing rapidly in the direction of producing alloys that resist corrosion and metals capable of meeting severe service conditions of pressure and temperature.

Many other chemical problems confront the power plant engineer in his daily work. Each plant has peculiarities which make them special problems and, until such problems are solved with the same surety that we meet our mechanical and electrical problems, our plant efficiency is bound to be below the best obtainable with the power systems now in general use.

THE PRINCIPLE of the inverted syphon so common today in hydraulic work was known to the Romans. In their water supply line for Lyons, France, they constructed such a syphon, consisting of 9 mi. of 12 to 18-in. lead pipe working under a 200-ft. head. At that time, iron pipe was unknown and the only available materials were wood, stone, lead and pottery. For this reason, the most economical method of crossing depressions, and the one most widely used was carrying the conduit on arches even though the inverted syphon was known and used upon occasion.



Power Plant Problems Discussed by Chemists

AMERICAN CHEMICAL SOCIETY MEETS AT INDIANAPOLIS, IND., MARCH 30 TO APRIL 3, TO DISCUSS PROBLEMS OF INTEREST TO POWER ENGINEERS PARTICULARLY IN CONNECTION WITH WATER TREATMENT, COMBUSTION AND LUBRICATION PROBLEMS

POWER PLANT PROBLEMS, particularly those dealing with feedwater treatment, fuel, combustion, and lubrication were discussed at the American Chemical Society meeting held at the Claypool, Lincoln and Severin Hotels at Indianapolis, March 30 to April 3.

Perhaps the most interesting papers to power plant engineers were: Factors influencing, priming and foaming, by C. W. Foulk, Kermit Groves and V. L. Hansley; Determination of the Sulphate-Carbonate Ratio for the Prevention of Sulphate Boiler Scale, by E. P. Partridge, W. C. Schroeder and R. C. Adams, Jr.; Silica Scale Prevention with Sodium Aluminate, by C. K. Christman, J. A. Holmes and H. Thompson, and Factors Influencing the Soap Test for Hardness, by R. H. Kean and H. Gustafson.

Another paper, Reactions of Sulphur Compounds in Boiler Furnaces, by H. F. Johnstone of the University of Illinois, outlined in some detail the work being carried on at the Engineering Experiment Station, particularly that part dealing with the control of corrosion. These investigations deal primarily with the oxidation of SO_2 to SO_3 so that it can be absorbed by water sprays and removed from the boiler and breeching. The work is, of course, one phase of the flyash and noxious gas nuisance which is becoming of increased importance to power plants in metropolitan areas.

Recent investigations in the laboratory and on experimental boilers at Ohio State University has done much to clear up the matter of foaming and priming. For some time an experimental boiler that primed more with distilled water than with concentrated salt solutions caused considerable speculation. In all cases, the throw-over of water into the steam line became less as the concentration of salt in the water increased. In order to find the reason for this action which is of course opposite to that which should be expected from theory and past experience, a glass boiler of the same design was made. It was found that the priming was caused by waves propagated along the drum. The crest of these waves hit the steam outlet and a slug of water was thrown out. With concentrated salt solutions, this wave effect was less, because of the small bubble formation. In distilled water, the steam bubbles combine to form larger bubbles which may completely fill the tube. In salt solutions, the small bubbles do not combine and the boiling action is much smoother.

In discussing the effect of finely divided solid matter on the foaming of salt solutions boiling at atmospheric pressure, Prof. Foulk stated that recent experiments have caused him to alter his former ideas about the effect of solid matter. All solid matter does not promote foaming as was formerly believed. Boiling experiments in specially constructed glass apparatus holding 4000 p.p.m. sodium chloride solution lead to the following conclusions: The nature of the solid matter is the determining factor in foaming, as certain substances such as ground flint have no foam stabilizing effect; boiler scale which greatly promoted foaming lost this property after the oil in it had been extracted; boiler scale and limestone lost their foam stabilizing effect after 2 to 10 hr. of boiling. As might be expected, finely divided particles which tend to float and form a surface scum promote foaming.

Scale prevention played an important part on the program. In one of the papers mentioned previously, E. P. Partridge outlined work carried on at the University of Michigan for the determination of the Sulphate-carbonate ratio for the prevention of sulphate boiler scale.

Hall's method of internal conditioning of boilers with soda ash depends upon a knowledge of the equilibrium ratio of sulphate to carbonate in a boiler water saturated with both calcium sulphate and calcium carbonate. Hall calculated this ratio by an indirect method, using an extrapolation of uncertain data for the solubility of calcium carbonate. This present paper described a direct determination of the SO_4/CO_3 ratio at 185 deg. C. (150 lb. gage pressure) based upon solubility determinations in complex solutions, including boiler-water analyses from boilers known to have been depositing scales of definite character. It was found that the critical SO_4/CO_3 ratio, with concentrations expressed in parts per million, is greater than 100, rather than approximately 11 as calculated by Hall for 185 deg. C. The new value of the ratio was checked by controlled scale-formation tests in an experimental electric boiler.

In another paper, Silica Scale Prevention with Sodium Aluminate, C. H. Christman told how the hard scale formed in boilers by silica is the cause of many tube failures and much heat loss and experimental data were presented to show the inefficient removal of silica in usual softening practice. Precipitation of silica in

softening and in boilers may be effected through the use of sodium aluminate, yielding a flocculent calcium or magnesium alumino-silicate. This precipitate has coagulating power and prevents the deposition of silica as scale. Silicate scale is prevented through removal of silica and hardness rather than by removal of hardness alone.

Experimental data on the purification of water by a commercial electro-asmose apparatus were presented by Edward Bartow and Floyd W. Perisho. The removal of the negative ions, chloride, carbonate, and sulphate, is practically complete at all rates below 30 liters per hour from solutions up to 250 parts per million. Bicarbonate ions are not easily removed from solutions of carbonate alone at rates in excess of 25 liters per hour, but are quickly removed from solutions containing sulphate or chloride ions. The limit of the machine is reached at 500 parts per million chloride radical if the rate is in excess of 25 liters per hour. If water of only comparative purity is desired, rates of 35 and even 40 liters per hour may be practical even with water of high salt content. Partially purified water may be prepared also by the use of fewer cells and without the necessity of washing the last two cells with pure water.

Serious errors in the determination of the residual hardness of zeolite-softened waters by the usual soap test may be caused by a number of factors which are frequently encountered in practice and which were enumerated by R. H. Kean and H. Gustafson. The influence upon the soap test of certain of these factors such as the temperature of the water, the presence of free carbon dioxide, variations in the alkalinity of the water, and in the concentration of certain sodium salts, has been investigated, and charts for correction of the errors introduced by these variables shown.

In the gas and fuel chemistry division papers, many subjects of interest were discussed including Studies in Adiabatic Calorimetry by S. W. Parr and W. D. Staley; Blue Coal, the Application of Color Trademarks by M. W. Weiss and G. J. Essenlen; Some Unit Studies of Virginia Coals by F. H. Fish and J. A. Addlestone; A Microscopical and X-Ray Study of Pennsylvania Anthracite by H. G. Turner and H. V. Anderson and the Mechanism of Combustion of Lump Coal by S. P. Burke and T. E. W. Schumann. With the exception of the Blue Coal discussion these papers were all of a theoretical nature of interest primarily to the laboratory technologist.

A simple bromine method of determining the total sulphur in gas was described by D. J. Demorest. The regular combustion method for the determination of organic and total sulphur in gases involves a great deal of trouble and the shorter method will be welcomed if its accuracy is satisfactory. Mr. Demorest found that a simple method of oxidizing the sulphur in gas with bromine in an ordinary gallon jug gives a sufficient size precipitation of barium sulphate to determine the amount of organic sulphur in ordinary gas. The method is simple and a large number of determinations can be run at a time.

Detailed studies of radiation in an internal combustion engine, by H. A. Smith and G. L. Clark described an apparatus with which most of the variables which include jacket temperature, intake air temperature, fuel, air-fuel ratio, charge density, spark timing, type of spark, location of spark plug, shape of combustion chamber, engine speed, load, knock, combustion pressure, wave length and intensity of radiation emitted, rate of flame propagation can be controlled. Preliminary experiments indicate that the average rate of flame propagation is 460 meters per second; a lean mixture emits a much larger amount of radiation of all wave lengths than a rich one; there is a notable change in ultra-violet and an increase in continuous visible radiation when we pass from a normal to a detonating flame; different parts of the same explosion will show a large difference in the intensity and type of spectrum obtained.

Photographic flame studies in the gasoline engine were made and described by Lloyd Withrow and T. A. Boyd. By means of an ingenious apparatus, simultaneous flame pictures and pressure record have been taken of events during the explosion of the charge in the cylinder of a gasoline engine. The flame pictures were taken with a fast camera through a narrow quartz window that extended all the way across the ceiling of the combustion chamber. The length and location of this window were such that the entire progress of the flame, starting at the spark plug and ending at the far end of the combustion space, was visible in the camera.

Synthetic lubricating oils now promise to take their place in the long lists of products which research has improved over nature. Lubricants made by synthetic chemistry were described in a paper by F. W. Sullivan, V. Voorhees, A. W. Neely and R. V. Shankland. Strangely enough these oils are made from paraffin wax, the constituent of petroleum which the oil industry has spent millions of dollars to find ways of removing from lubrication oils. The new oils can be made in any desired viscosity, they have a pale straw color, high resistance to oxidation and sludging, a very low power test and low volatility. Above all the new oil is more resistant to temperature changes than known natural oils. This prevents its thinning and losing body at high temperatures and excessive thickening at low temperatures.

Progress at Ariel Hydroelectric Project

AT ARIEL, WASHINGTON, the $8,500,000 hydroelectric project now under way represents the initial stage of power development on the Lewis River, which offers unusual possibilities for the storage and regulation of its water supply.

The Ariel development is the project of the Inland Power and Light Co., an Oregon corporation. The dam, power plant and other permanent improvements are being built by the Phoenix Utility Co., under a general contract. On completion, the entire property will be taken over by the Northwestern Electric Co., of Portland, as lessee, by which it will be operated.

The present project is the first of developments whereby as rapidly as future demands for power warrants, a series of dams and lakes will be created. The ultimate cost of the entire development is estimated at $12,500,000.

Construction was begun October 24, 1929, and the work will be completed, it is expected, late in 1931. Plans called for a dam to create a reservoir for 220,000

FIG. 1. RECENT VIEW OF ARIEL DAM UNDER CONSTRUCTION ON LEWIS RIVER

acre-feet of useful storage and a power plant providing for the ultimate installation of four 45,000-kw. generating units. The dam will be 314 ft. high, 1000 ft. long on top and 100 ft. wide at the bottom. The thickness of the reënforced concrete will vary from 16 ft. at the top to approximately 95 ft. at the base of the structure. The dam is a combination arch and gravity type.

The diversion tunnel, costing $600,000, was completed last summer. It is 25 ft. in diameter, lined with concrete. It has a carrying capacity of 18,000 cu. ft. per sec. Upon completion of the dam, a large wooden flood gate will be placed over the upper end of the tunnel to keep out the water temporarily, then the tunnel will be plugged with concrete.

After the tunnel was completed and the river diverted, excavation was started for the foundation of the dam. Due to the existence of a narrow, buried channel, in order to reach bedrock it was necessary to excavate to a depth of 123 ft. below the natural stream bed, or to a point almost 74 ft. below sea level.

The plans provide for the ultimate installation of four steel penstocks, each 15.5 ft. in diameter and four 45,000-kw. generating units in the steel and concrete powerhouse immediately below the dam. The first generating unit, to be placed early in 1931, will consist of an S. Morgan Smith hydraulic turbine and a General Electric 13,000-v., 45,000-kw. generator, the turbine operating at a maximum head of 185 ft.

Voltage will be stepped up from 13,000 v. to 110,000 v. for transmission by three 18,750-kv-a. General Electric transformers. Auxiliary switching equipment is being supplied by Allis-Chalmers Manufacturing Co.

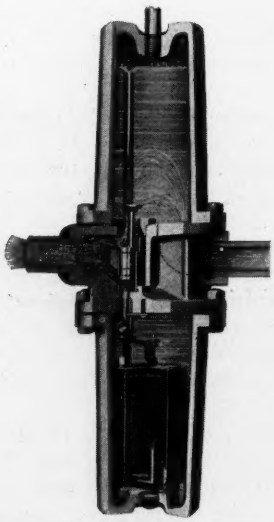
FIG. 2. ONE OF THE GENERATORS FOR ARIEL PROJECT, RATED AT 52,650 KV-A., UNDER CONSTRUCTION

Compound Steam Trap

ARMSTRONG COMPOUND Trap, shown here, was developed to overcome the troubles sometimes experienced with piston operated traps. It is designed for few moving parts, simplicity and high capacity for a given diameter of discharge orifice.

Design and construction are intended to give practically attentionless operation. If it becomes necessary to inspect the operating mechanism, all parts are easily accessible without disturbing the inlet or outlet connections. The keynote claimed for its design is extreme simplicity; in the pilot trap there are only two moving parts, the inverted bucket and valve lever and in the pilot housing the only moving parts are the piston and main valve, which are integral and designed to operate in unison.

The body of the compound trap consists of standard Armstrong trap bodies bolted to a piston housing. In the No. 230 series compound traps, for pressures up to 250 lb., the piston housing and bodies are of close-grained semi-steel of high tensile strength, containing nickel and chromium. For high temperature, high pressure duty, the bodies are one-piece forgings, while the piston housing is machined from a solid steel billet.



DETAILS OF CONSTRUCTION OF NEW ARMSTRONG COMPOUND TRAP

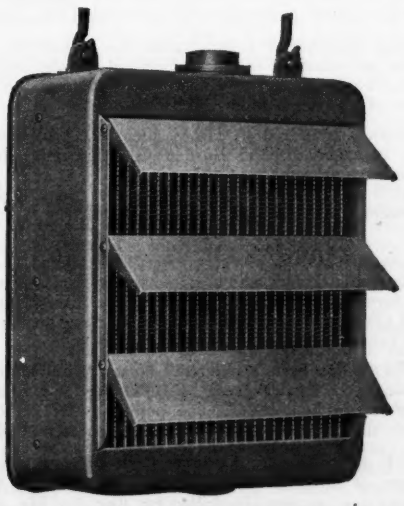
This construction is intended to make the entire trap mechanism accessible. After removing the receiving chamber body, the piston valve seat can be unscrewed. It is then a simple matter to pull out the main valve and piston, as well as the piston liner.

No springs are used in the new trap. With the vertical piston and liner, the main valve is made to close by gravity. To prevent excessive opening of the main valve, a combination of pressure relief port and partial closing of the main discharge port is employed. This makes a water brake to prevent excess opening of the main valve. Large water passages through the trap and practically straight-line flow are used to give this trap high capacity in proportion to the main valve area. Oversize inlet and outlet connections are provided, so that the discharge orifice will be the limiting factor of capacity instead of pipe friction. Its maker is The Armstrong Machine Works, Three Rivers, Mich.

Unit Heater in Colors

EXPRESSLY DESIGNED for meeting the special requirements of offices, stores, and theatres, the 12-A Uniheat of the Perfex Corp., Milwaukee, Wis., can be used to provide all of the heat, or to supplement direct radiation in heating cold or exposed parts of reception rooms, lobbies, private offices, or other rooms requiring distributed heat. It combines features that make it ideal for such applications: quiet operation; extreme compactness; trouble-free operation and pleasing appearance.

Heating core is copper and bronze from inlet to return, a distinctive Perfex feature. Copper offers the highest possible conductivity of heat and the use of a large number of copper fins, firmly united with the vertical tubes, assures the greatest possible amount of heat dissipation. The tubes are flattened to minimize air resistance and are made of extra heavy gage metal. By carefully brazing the tubes to the header plates and the plates to the headers, the entire heating unit is virtually one piece of copper. Unlike the ordinary heater with cast or malleable headers, the Perfex Uniheat is non-corrosive from inlet to return.



PERFEX CORP., NO. 12A UNIHEAT FURNISHED TO MATCH INTERIOR DECORATION

Two angle clips with holes are provided for suspending the unit from the ceiling facilitate installation. This relieves the steam line of all strain and also relieves the heating section from the expansion and contraction strains of the piping.

Neatness of the cabinet and excellent proportions of the unit are apparent. Standard finishes are walnut, sage green, and old ivory. It may also be ordered in any special finish to match the interior decoration. The cabinet measures 14⅝ in. high, 12⅜ in. wide and 5 in. deep and is capable of delivering 181 sq. ft. of radiation at 5 lb. steam pressure.

Enclosed Type Governor

PICKERING GOVERNOR with moving parts enclosed as shown in the illustration, is now supplied as standard equipment on many leading makes of engines, it is stated. This improvement has been developed by the Pickering Governor Co., Portland, Conn., to meet the needs of those installations where the enclosed feature is a safety factor.

GOVERNOR PARTS ENCLOSED FOR SAFETY AND CLEANLINESS

It also makes for cleanliness of machinery and excludes dust and dirt from the enclosed parts. This improvement is also in line with modern engineering tendencies for smoother design and appearance.

News Notes

TWENTY-FIFTH ANNUAL CONVENTION of the Illuminating Engineering Society is scheduled to be held at Pittsburgh, Pa., from October 13 to 16, inclusive, 1931, with headquarters at the William Penn Hotel. As in previous years, a session of the Lighting Service Engineers will be held on the day preceding the official opening of the convention. A special feature of this year's meeting will be the observance of the Society's Silver Anniversary.

UNITED ENGINEERS & CONSTRUCTORS, INC., Philadelphia, secured new contracts in 1930 for engineering and construction work in the United States totaling $62,861,843, according to a recent announcement by Dwight P. Robinson, president.

The work executed by the company during the year totalled $68,500,000 and is believed to be the largest volume of work done by any company in this country last year.

Among the many undertakings handled in the United States and abroad, were the following: for the Illinois Steel Co., South Chicago, Ill., a new 96-in. continuous plate mill and a 20,000-kw. steam power station; design and construction of additions to the plant of the American Potash & Chemical Corp., Trona, Cal.; construction of Lock and Dam No. 8 for the United States Gov-

ernment on the Allegheny River near Kittanning, Pa.; miscellaneous industrial plants for the American Can Co.; Pittsburgh Plate Glass Co.; Westinghouse Electric & Manufacturing Co. at Newark, N. J.; General Fire Extinguisher Co., Philadelphia; Barber Asphalt Co., Maurer, N. J.; 207-mi. pipe line from Reading, Pa., to Syracuse, N. Y., for the Susquehanna Pipe Line Co., a subsidiary of the Sun Oil Co.; construction of substations, service buildings, office buildings, garages, etc., for the Public Service Electric & Gas Co., Newark, N. J., and the Philadelphia Electric Co.

F. C. THOMPSON, vice-president and general manager of Morse Chain Co., Ithaca and Detroit, subsidiary of Borg-Warner Corp., announces the appointment of R. W. Appleton as purchasing agent at Ithaca, N. Y. Mr. Appleton was formerly director of purchases of Pierce Arrow Motor Car Co.

H. W. GREIDER has been appointed director of research for The Philip Carey Manufacturing Co., Lockland, Cincinnati, Ohio. He was for several years the incumbent of the company's industrial fellowship on magnesia products at the Mellon Institute of Industrial Research and more recently has been engaged in research and development work at its Plymouth Meeting, Pa. and Lockland, Ohio plants. The investigation on heat insulation which has been in progress at the Mellon Institute for the past 14 yr. under the direction of R. H. Heilman is being continued.

A new research laboratory is under construction at Lockland, and will be operated in addition to the company's production control laboratory, the latter being directed by C. J. Pater, chemical superintendent.

AMERICAN CHAIN CO., INC., in its annual report to its stockholders, has announced that one of its subsidiaries, the American Cable Co., has concluded negotiations with the American Steel and Wire Co. to manufacture preformed wire rope under a license agreement, the patents covering this material being owned by the American Cable Co.

Preformed wire rope has the wires and strands preformed and pre-shaped to the exact helical "lay" which they assume in the finished rope, giving freedom from internal torsional stress, which it is claimed, substantially increases the length of service.

ACCORDING to a recent announcement work will begin on two major projects during 1931 at the Kearny generating station; one project is a 20,000-kw. mercury vapor boiler and turbine-generator and the second that of a 75,000-kw. steam turbine-generator together with addition of water walls on 11 boilers. This work is to be carried out by the United Engineers & Constructors, Inc.

GEORGE G. LANDIS has been advanced to chief engineer of the Lincoln Electric Co., Cleveland, Ohio.

FRANCIS HODGKINSON, consulting mechanical engineer of the Westinghouse Electric and Manufacturing Co., South Philadelphia Works, has been awarded the Willans Premium, a distinguished British engineering honor, by the Institution of Mechanical Engineers of London.

This award was given for the best paper published in the proceedings of the Institute from 1925 to 1930 inclusive, and is being forwarded him in the form of a gold medal.

Hodgkinson, well-known in marine circles for many contributions to improvement and efficiency in steam-propelling machinery and electrical apparatus, was formerly associated with the late Sir Charles A. Parsons in his early turbine experiments and developments in England.

GEORGIA POWER AND LIGHT CO., operating subsidiary of Seaboard Public Service Co., reports operating revenues for 1930 of $1,129,419, compared with $1,108,922 for 1929. Total income available for bond interest was $373,703, compared with $329,151 in 1929. Net income available for dividends and surplus for the year was $137,503, compared with $121,009 in 1929. Report of Keystone Public Service Co., one of the operating subsidiaries of Municipal Service Co., for the year 1930 shows operating revenues of $1,510,468, compared with $1,556,922 in 1929.

Penn Central Light & Power Co., a subsidiary of National Electric Power Co., reports operating revenues for 1930 of $5,921,242, a 4.4 per cent increase over 1929, when revenues were $5,679,846.

Balance available for bond interest was $3,763,575 in 1930, compared with $3,317,117 in 1929. Net income available for dividends and surplus for the year was $2,093,538, compared with $1,687,852. These companies are part of the Middle West Utilities System.

BENJAMIN H. SNOW has been appointed division sales manager of the Bernitz Furnace Appliance Co. of Boston, Mass. The division includes New England States, New York and Northern New Jersey. L. R. Leatherman who has been associated with the company as district sales manager in other territories, is transferred to the New York office of the company. F. G. Schneeberg, Jr. will be associated with Mr. Leatherman and will handle sales in Upper New York State and Northern New Jersey.

HALFORD ERICKSON, vice president in charge of operation, Bylesby Engineering and Management Corp., announces that work will soon be started by The California Oregon Power Co. on the construction of a regulating dam at Keno, Oregon, on the Klamath River. This new dam will cost approximately $100,000 and will furnish employment for a considerable number of men. The completion of this project will aid materially in regulating the flow of the Klamath River between Klamath Falls and Keno and is expected to overcome the problems formerly caused by the fluctuation of the stream flow. This will greatly benefit the operations of riparian land owners along the river from Klamath Falls to Keno it is claimed, as well as proving a big help to timber interests and navigation in that vicinity.

The new Keno dam, which is being built for the purpose of regulation only, will be 8 ft. high and approximately 1200 ft. long including the earth embankments on each side. The structure will be what is termed a needle dam and will consist of timber crib with continuous concrete sill and earth filled dam. A timber operating bridge will extend throughout the entire length of the structure. There will be two large Tainter gates in the spillway section, each of which will be 5 ft. 6 in. by 15 ft. in size. These gates will be of structural steel construction with the gate faces of timber.

Work will start soon upon the construction of a rock filled timber crib coffer with upstream sheeting and earth banking to unwater the site of the structures and the excavated channel. In accordance with the usual policy of The California Oregon Power Co., local labor will be used to the greatest possible extent throughout the entire project.

CHARLES SPAFFORD BLAKE, chairman of the board of the Hartford Steam Boiler Inspection and Insurance Co. of Hartford, Conn., died on March 31. Mr. Blake was born in Windsor Locks, Conn., in 1860, educated in the public schools of Springfield, Mass., and Jersey City, N. J., and after a period spent in newspaper work, served an apprenticeship at the Central Iron Works, Jersey City. He served for a period in marine engineering and then entered the boiler insurance field in 1884 as an inspector for the American Steam Boiler Insurance Co. He joined the Hartford Steam Boiler Inspection and Insurance Co. in 1898 as its general agent in Hartford and 6 yr. later was advanced to the position of supervising general agent. In 1907 he was elected the second vice-president and a year later was made secretary. He served in that capacity until 1916 when he was made a director and at the same time elected to the presidency. He was made chairman of the Board of Directors on February 8, 1927.

TO MEET increasing demands for its products and otherwise to improve its service to customers, Metallo Gasket Co. has just completed a two-story brick addition to its plant at New Brunswick, New Jersey, which more than doubles the previous floor space. Much new equipment has been ordered and individual motor drive is being installed throughout the plant.

HAMMITT-CROZIER CO., Kansas City, Mo., has been appointed district representatives of the Strong-Scott Manufacturing Co. of Minneapolis, for Kansas, Nebraska and Western Missouri.

ANNOUNCEMENT IS MADE by L. Mundet & Son, 461 Eighth Ave., New York City that H. B. Villiers, a specialist in the elimination of vibration and noise, has been appointed head of its recently created department of Natural Cork Isolation.

RELIANCE ELECTRIC & ENGINEERING CO., Cleveland, Ohio, announces the advancement of M. C. Suerken to sales representative of its New York Office and Robert M. FitzGerald to sales representative of its Philadelphia Office.

FIVE YEARS AGO Alfred F. Howe, then vice president and general sales manager of The Borden Co., Warren, Ohio, retired from business and went to California.

On March 1 Mr. Howe returned to the company as western sales manager with headquarters at 717 Calmar Ave., Oakland, Cal.

RILEY STOKER CORP. of Worcester, Mass. and Badenhausen Corp., Cornwells Heights, Pa. announce a consolidation which puts the former corporation in position to furnish fuel burning and steam generating equipment under a single contract with guarantees on overall efficiency and capacity.

J. B. FOLEY has been appointed Chicago Branch manager for Goulds Pumps, Inc. to relieve P. F. O'Donnell, who has given 40 yr. of service in handling Goulds pumps. Mr. O'Donnell continues with the organization special sales representative.

EDWIN T. HALL has been appointed by Sullivan Machinery Co. as manager of it Boston office to succeed the late George H. Richey who was accidentally killed on Apr. 1. Mr. Richey had been in his position since 1919 and Mr. Hall has been associated with the New England sales district for the past 15 yr.

NORTH AMERICAN LIGHT & POWER CO. of Chicago, Ill., according to its annual report just issued, showed an increase in gross earnings of $1,351,042.56 or approximately 3 per cent as compared with the earnings for 1929. The balance of income available for dividends on the cumulative preferred stock was $5,409,955.98 on December 31, 1930. Income available for dividends on the common stock increased from $3,562,248.26 in 1929 to $4,250,455.98 in 1930 or 19.3 per cent.

WALTER H. WIEWEL has been made sales manager of The Timken Steel & Tube Co., Canton, Ohio, replacing A. J. Sanford, resigned. Mr. Wiewel has been associated with the company for several years as manager of steel sales in New York City. He will make his headquarters at Canton, Ohio.

THREE NEW DIRECTORS have been added to the Board of Link-Belt Co.; Arthur L. Livermore of New York, George P. Torrence, vice-president in charge of Indianapolis plant since 1928, Richard W. Yerkes, secretary and treasurer, formerly sales manager at Philadelphia.

BRISTOL'S TRIPLEX RECORDING AMMETERS, recording on three circular 6-in. charts in one meter and designed to furnish continuous chart records of currents in all three lines of polyphase feeders, is described and illustrated in a new bulletin, No. 374 by The Bristol Co., Waterbury, Conn.

MEXKO firebrick placed on the market last year is described in detail by A. P. Green Fire Brick Co., Mexico, Mo., in a new 24-page bulletin. The bulletin presents data regarding the resistance of this brick to spalling, its ability to keep its shape, its load bearing properties, thermal expansion, chemical properties and refractoriness.

PIONEERS IN GAS PRESSURE REGULATION, is the title of a new 60-page, well-illustrated bulletin issued by National Gas Equipment, Inc., 1123 Harrison St., San Francisco, and Petroleum Securities Bldg., Los Angeles, Calif. This bulletin discusses first the general considerations of operation with natural gas, describes Wilgus regulators for reducing back pressure, gas fuel, pump and compressor governing, and other services, Wilgus motor valves, vacuum and differential regulators, N.G.E. liquid level controllers, and so on. Details are given of the various types of regulators with tables of dimensions, layout diagrams, installation blueprints and photographs of installations.

Catalog Notes

POWER TYPE PRESSURE DEVICES for remote master pressures indicators and recorders and other uses are described and illustrated in bulletin No. 70 just issued by Bailey Meter Co., Cleveland, Ohio.

IN AN INTERESTING illustrated 12-page folder, discussion of who gets the steam and how to find out by use of the Brown flowmeter is given by the Brown Instrument Co., Philadelphia, Pa:

KIPS BAY Station of the New York Steam Corp., particularly the fifth steam generating unit, is described in a booklet issued by Combustion Engineering Corp., 200 Madison Ave., New York City. This last unit has a guaranteed capacity of 700,000 lb. of steam per hour, but has actually produced steam at a rate in excess of 1,000,000 lb. per hr.

STEAM PURIFIERS and oil separators are described in detail in a new illustrated bulletin, No. 9-P issued by Schutte & Koerting Co., Philadelphia, Pa. The SK diffuser steam purifier, both external and internal types, is described in detail, also the SK adhesion oil separator, with color charts and diagrams showing how they are applied to boilers and turbines.

GOULDS PUMPS, INC., Seneca Falls, N. Y., describes a new line of centrifugal pumps in a folder recently issued with capacities from 10 to 1100 g.p.m. and for heads up to 350 ft.

BULLETIN 71-J has just been issued by Sullivan Machinery Co., Chicago, Ill., describing the Air Made Well for pneumatic pumping of sand and silt strata. This method, which combines the special well construction engineering of the Air Made Well Co. of Kansas City, and Sullivan air lift equipment and methods, is used to develop water supply from shallow sand and gravel strata.

SYLPHON AUTOMATIC RADIATOR VALVES, a device for regulating steam supply to radiators under the control of a thermostat which is part of the radiator valve itself are described in detail in a recent 10-page folder by Fulton Sylphon Co., Knoxville, Tenn. The bulletin also gives details of the Sylphon No. 11 Regitherm, consisting of a radiator valve actuated by a Sylphon thermostat through a tube.

SMALL HEAVY DUTY WORM GEAR SPEED REDUCERS are described in new catalog No. 135 by D. O. James Mfg. Co., 1120 W. Monroe St., Chicago, Ill. Details of these reducers are shown by photographs and drawings. The bulletin contains tables of dimensions of layout sketches and by means of photographs shows the application of reducers to many industrial processes.

DUAL-DRIVE EXCITER SETS, 25 to 500 kw. consisting of a mechanical-drive turbine, a direct-current generator and an induction or synchronous motor, all mounted on a continuous bedplate are described in detail in a recent bulletin, issued by Westinghouse Elec. & Mfg. Co., South Philadelphia Works, Philadelphia, Pa.

THERMIX dust collectors of two types, one utilizing the fan scroll and the other utilizing several cyclones arranged in parallel, are described in detail in a new bulletin issued by Prat-Daniel Corp., 183 Madison Ave., New York City.

DIAMOND VULCANIZED FIBRE, its manufacture and the uses to which it has been put by various industries are discussed in a recent 40-page bulletin published by Continental Diamond Fibre Co., Newark, Del.

MERCO SWIVEL FLANGES, as recently described in Power Plant Engineering, are discussed in detail with tables of dimensions in a new 8-page bulletin of the Merco Nordstrom Valve Co., 121 Second St., San Francisco, Calif.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly at Chicago, Ill., for April, 1931.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary in and for the State and county aforesaid, personally appeared Arthur L. Rice, who, having been duly sworn according to law, deposes and says that he is the Editor of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
Madge W. Rice, Wilmette, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.
R. E. Turner, Chicago, Ill.
A. W. Kramer, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustees or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

TECHNICAL PUBLISHING CO.,
ARTHUR L. RICE, Editor.

Sworn to and subscribed before me this 21st day of March, 1931.

[Seal.] EDDIE H. KAHL,
Notary Public.

(My commission expires March 20, 1932.)

Power Plant Construction News

Calif., Anaheim—The Golden State Citrus Products Co., Anaheim, has completed plans for a new one-story ice and precooling plant, 55 by 105 ft., to cost about $75,000, with equipment. H. A. Hamm, 2145 Sacramento Street, Los Angeles, Calif., is architect.

Calif., Antelope—The California Lime & Products Co., Lincoln, Calif., plans installation of electric power equipment in connection with new hydrate lime plant and dry-ice manufacturing plant at Antelope, on which work will soon begin, entire project reported to cost over $150,000. The Smith Emery Co., 651 Howard Street, San Francisco, is engineer.

Calif., Redwood City—The National Silicate Products Co., 63 Bluxome Street, San Francisco, plans installation of electric power equipment in proposed new cement mill near Redwood City, for production of quick-drying cement, entire project to cost over $150,000. A boiler house is proposed.

Conn., New London—The Bureau of Yards and Docks, Navy Department, Washington, D. C., has plans for a Diesel engine laboratory at the submarine base at New London, reported to cost close to $50,000, with equipment.

Idaho, Driggs—The Board of Village Trustees, Driggs, is said to be considering the installation of a municipal electric light and power plant. Estimates of cost will be made at an early date.

Ill., Metropolis—The C. C. Leonard Woodworking Co., Metropolis, plans installation of motors and other electric power equipment in connection with proposed rebuilding of portion of woodworking mill, recently destroyed by fire with loss of about $100,000.

Ind., East Chicago—The Board of School Commissioners, East Chicago, plans installation of motors, controls and other electric power equipment in proposed new industrial school on East 140th Street, entire project reported to cost over $300,000.

Ind., Fort Wayne—The Board of Trustees, Indiana School for Feeble-Minded Youth, Fort Wayne, has plans under way for a new power plant at institution, including improvements in heating system. An appropriation of $195,000 has been secured for the work. R. W. Noland, Cal-Wayne Building, Fort Wayne, is engineer.

Ind., Salem—The Kraft-Phoenix Cheese Co., Salem, plans installation of a cold storage and refrigerating plant in connection with an expansion program at local plant, entire project reported to cost over $60,000. R. E. Brown is manager.

Iowa, Cedar Rapids—The Universal Crusher Co., C Avenue, contemplates the installation of motors and other electric power equipment in connection with proposed addition to crushing and pulverizing machinery manufacturing plant, entire project reported to cost about $50,000. William L. Harrison is general manager.

Iowa, Fort Dodge—The Fort Dodge Gas & Electric Co., Fort Dodge, has filed plans for an addition to steam-operated electric power plant, 35 x 75 ft., to cost over $150,000, with equipment. Company engineering department is in charge.

Ky., Harlan—The City Council has plans under way for a municipal electric light and power plant. Estimates of cost are being made. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is engineer.

Ky., Louisville—The Louisville Water Co., Louisville, is said to be planning installation of pumping machinery and auxiliary equipment in connection with an expansion and improvement program in municipal waterworks, entire project to cost over $1,000,000.

Md., Baltimore—August Maag Co., Haven and Fleet Streets, plans installation of electric power equipment in new three-story addition to tinware manufacturing plant, entire project to cost over $150,000. Work will be placed under way at an early date. Company is affiliated with the Edward Katzinger Co., 1949 North Cicero Avenue, Chicago, Ill., Lockwood, Greene Engineers, Inc., Wrigley Building, Chicago, is architect and engineer.

Mich., Detroit—The Dependon Chemical Co., 4488 Lawton Street, is said to be planning the installation of electric motors and other power equipment in connection with proposed rebuilding of portion of metal polish manufacturing plant, recently destroyed by fire with loss of about $70,000.

Miss., Canton—The City Council, Canton, is planning rebuilding of portion of municipal electric light and power plant, and waterworks, recently destroyed by fire with loss reported at $50,000.

Miss., Jackson—P. N. Biewer, Jackson, and associates have plans for a one-story ice-manufacturing plant, with capacity of about 30 tons per day, estimated to cost close to $50,000, with equipment.

Miss., Starkville—The Common Council, Starkville, has tentative plans under way for a municipal electric light and power plant. Estimates of cost will soon be made. Swanson & McGraw, Balter Building, New Orleans, La., are consulting engineers.

Mo., Ellington—The Van Buren Light, Power & Ice Co., Ellington, is planning rebuilding of portion of local power station, recently damaged by fire with loss of about $35,000, including equipment.

Mo., Kansas City—The Southland Cottonseed Products Co., First and Troost Streets, is said to be planning installation of motors and other power equipment in connection with proposed rebuilding of portion of mill recently destroyed by fire, with loss estimated at $50,000.

Mo., Kansas City—The Chicago, Rock Island & Pacific Railroad Co., 179 West Jackson Blvd., Chicago, Ill., is said to be planning construction of a new car-icing plant at Kansas City, to cost about $300,000, with equipment. Company engineering department will be in charge.

N. Y., Batavia—Department of Public Works is considering the installation of a central steam heating system in the business district, expanding present facilities at city lighting plant and installing pipe lines, pressure equipment, etc. Estimates of cost will soon be made. Roy S. Henderson is superintendent.

N. Y., Buffalo—The Hecker-H-O Co., Genesee Building, plans installation of electric power equipment; elevating, conveying and other mechanical apparatus, in new addition to grain elevator at 54 Fulton Street, entire project to cost about $500,000.

N. Y., New York—The Consolidated Gas Co., 4 Irving Place, New York, has acquired tract of land on West Farms Road, fronting on Bronx River, Bronx, totaling 130,000 sq. ft., and plans construction of a new central distributing plant, reported to cost over $500,000, with equipment. Company engineering department is in charge.

Ohio, Rossford—The Pure Oil Co., Wabash Avenue and Wacker Drive, Chicago, Ill., plans installation of compressor stations and other mechanical equipment in connection with new natural gas pipe line to Rossford plant of Libbey-Owens-Ford Co., for service in glass manufacture, entire project to cost about $1,000,000. Company engineering department is in charge.

Texas, Beaumont—The Decker Packing Co., Mason City, Iowa, has plans under way for a cold storage plant on Crockett Street, Beaumont, reported to cost over $40,000, with equipment. C. R. Heartfield, Goodhue Building, Beaumont, is engineer.

Texas, Brownsville—The City Council, Brownsville, is planning extensions and improvements in light and power plant, and municipal water-works, to cost about $150,000, with equipment. A bond issue in amount noted is proposed.

Texas, Crystal City—The Shippers Co-Operative Ice Co., care of J. L. Price, president, recently organized by Mr. Price and associates, is planning the construction of a local ice-manufacturing plant with capacity of 150 tons daily, reported to cost about $175,000. A cold storage plant will also be built. Mr. Price is president of new company; C. R. Jarratt is vice-president.

Texas, Rio Grande City—The Central Power & Light Co., San Antonio, has completed plans for a one-story ice-manufacturing plant at Rio Grande City, reported to cost close to $40,000, with equipment. John M. Marriott, San Antonio, is architect.

Wis., Milwaukee—The Plankinton Packing Co., Milwaukee, plans installation of electric power equipment in proposed six-story addition to meat-packing plant, entire project to cost close to $100,000.